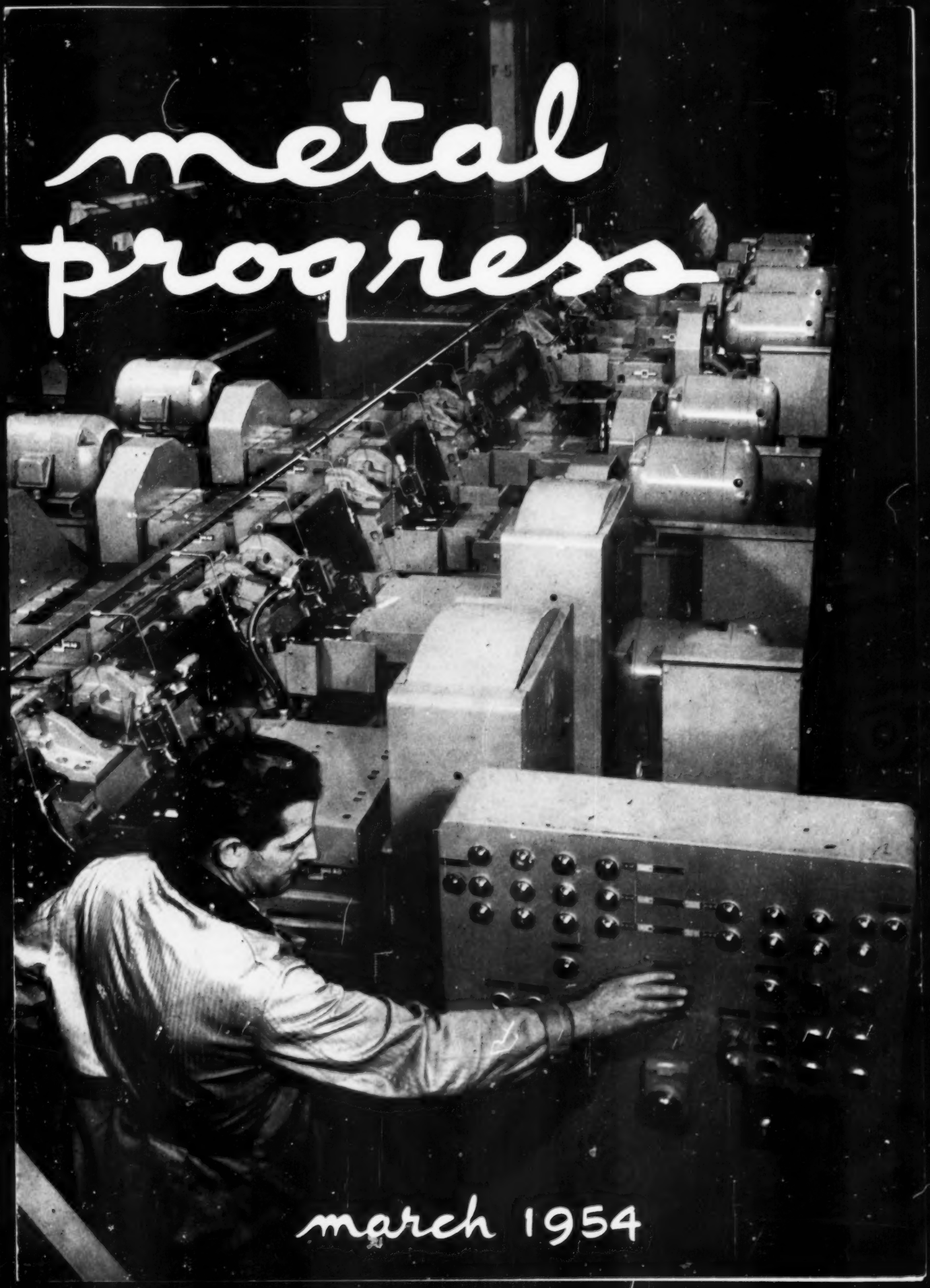
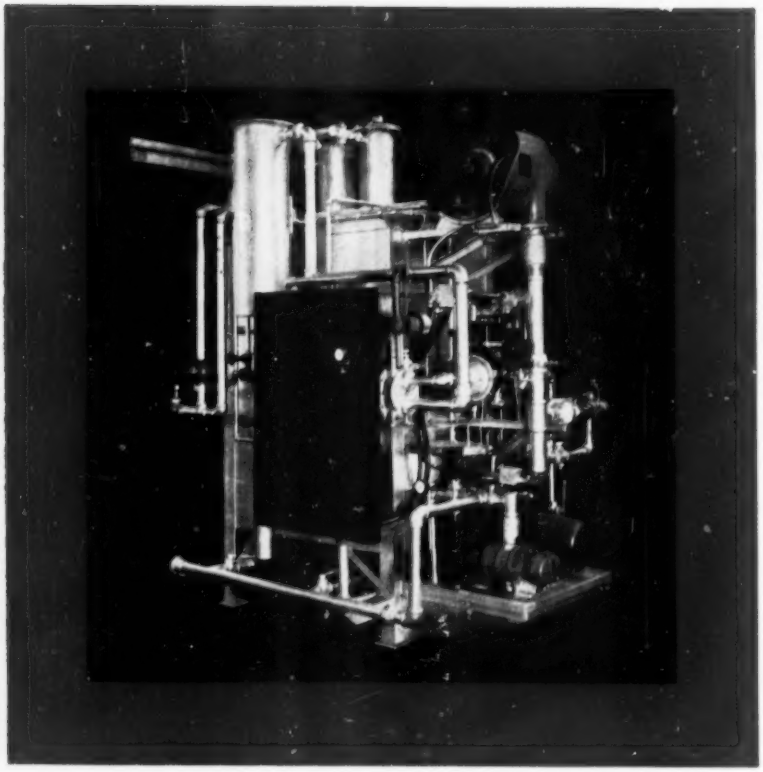
metal progress



march 1954

KNOW WHAT YOU GET

RX DX NX HNX AX HX



There's a fourth dimension in every atmosphere generator, which makes a significant difference in Heat Treat productivity and equipment earning power. It's the number of *previous successful applications* which, in the case of Surface generators, runs literally into thousands. Indeed, they go back to 1929, the year of the first use of a neutral atmosphere for controlling oxidation of non-ferrous metal. If you want the best guarantee that specifications will be met or exceeded, specify 'Surface.' The latest and most authoritative data on gas atmospheres are presented in our bulletin SC-155. We'll be glad to send you a copy.

***Specify* SURFACE COMBUSTION ATMOSPHERE GENERATORS**

POCKET-GUIDE

TO GAS ATMOSPHERES FOR ALL REQUIREMENTS

GAS	CAPAC. c.f./hr.	APPLICATIONS
RX	250 to 5600	carburizing, dry cyaniding, brazing, sintering, bright annealing, clean hardening, carbon restoration (skin recovery)
DX LEAN	250 to 35,000	bright annealing and sintering (copper)
DX RICH	250 to 35,000	bright annealing, brazing (low and medium carbon steel)
NX	2500 to 20,000	bright annealing (copper, carbon steel), clean hardening (medium carbon steel)
HNX	5000 to 20,000	extra bright annealing (copper, low carbon steel), clean annealing (stainless steel)
AX	100 to 4000	rapid de-oxidation of surface metal, brazing, sintering (low carbon steel), bright annealing (stainless)
HX	1000 to 15,000	rapid de-oxidation of surface metal (low carbon steel), bright annealing (stainless)

This condensed table of Surface Combustion prepared atmospheres (designations are trademarked) shows at a glance how broad a range of heat treat requirements they meet. Specified gas compositions are accurately and economically maintained, over the entire range of capacities. Your nearby Surface representative can draw from an unequalled fund of industry-wide experience, and recommend equipment best suited to your job. Bulletin SC-155 presents 8 solid pages of valuable data.

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

ALSO MAKERS OF

Kathabar HUMIDITY CONDITIONING *Janitrol* AUTOMATIC SPACE HEATING

Metal Progress

March, 1954 Vol. 65, No. 3

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Cover shows automatic machine line for automobile engines. Photo courtesy of Ford Motor Co. and Heald Machine Co.

Engineering Articles

Metallurgist Assesses Impact of New Automatic Control Mechanisms, by Arthur H. Allen . . . 65
Design and Construction of Needle Thermocouples, by W. Gerard Rauch . . . 71
The Quality of Toolsteel – Recent Developments and Future Predictions, by Burns George . . . 75
Project Tinkertoy – Mechanized Manufacture, Inspection and Assembly . . . 81
Protection of Hot Work Tools in Heat Treatment, by J. Y. Riedel . . . 85
Surface Hardening Processes for Titanium and Its Alloys, by R. W. Hanzel . . . 89
Metallurgical Education in the United States, by Alfred Bornemann . . . 97
German Investigations on Boron Steels, by Robert Scherer and Karl Bungardt . . . 101
Portable Ultrasonic Instruments, by Peter K. Bloch . . . 161

Critical Points

Welded Joints in Stainless Equipment . . . 79
Launching of the Nautilus . . . 79

The Atomic Age

The Road Ahead; Extracts From an Address by Thomas E. Murray . . . 107

Correspondence

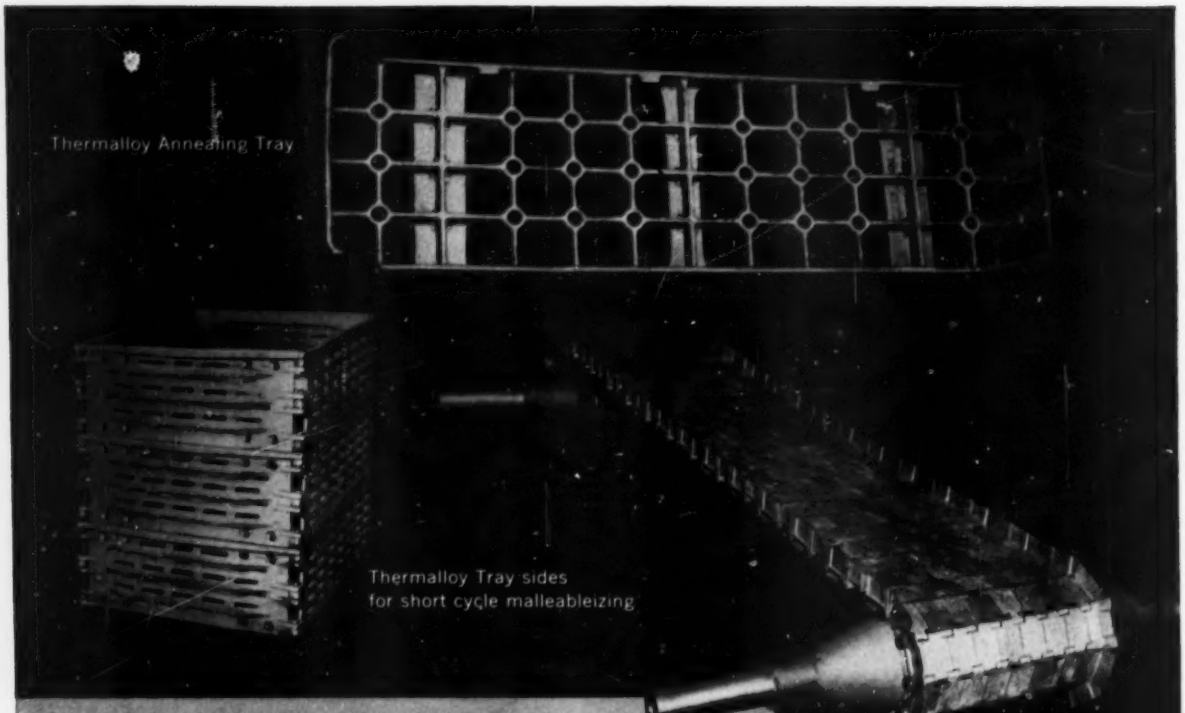
Sharpness Tester for Razor Blades, by Keizo Iwase . . . 112
Open-Circuit Couples, by C. J. Thwaites . . . 114

Digests of Important Articles

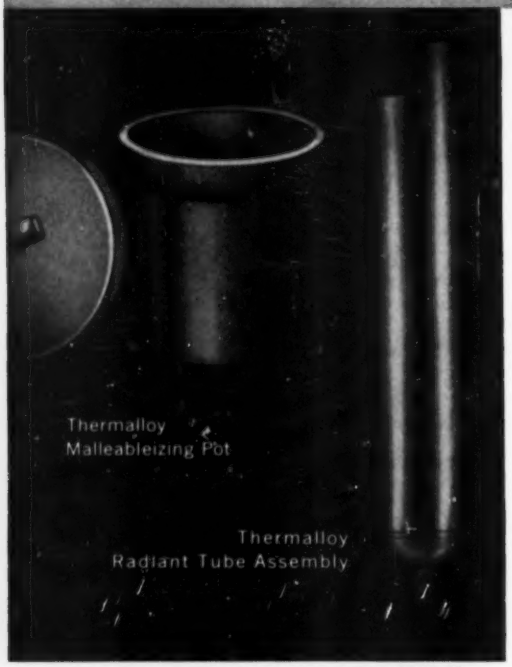
Recrystallization Behavior of Aluminum . . . 130
Test Instruments Using Eddy-Current Principle . . . 134
Testing the Tendency to Stress-Corrosion Cracking . . . 140
Oxygen in Iron-Vanadium Melts . . . 178
Intracrystalline Voids in Magnesium Alloys . . . 182
Production of Sound Castings . . . 186
Improved Method for Reduction of Iron Powders . . . 192
Remedy for Hydrogen in Brass Sheets . . . 196
Crucibles for Difficult Jobs . . . 198

Departments

As I Was Saying–Bill's Column . . . 3
Book Review: Role of History in Evaluating Metals; Review by John R. Townsend of "History of Strength of Materials" by Stephen P. Timoshenko . . . 87
Data Sheet: Directory of Degree Programs in Metallurgy, Compiled by A. Bornemann . . . 96-B
Short Runs . . . 108
Personals . . . 116
Engineering Digest of New Products . . . 9
Manufacturers' Literature . . . 21
Advertisers' Index . . . Last page



THERMALLOY*
HEAT-RESISTANT CASTINGS



Can help cut heat-treat costs

Here are a few of the many high heat-resistant Thermalloy castings that can help you cut heat-treat costs. Whether it's a standard tray, basket, pot or radiant tubes . . . or a specially-designed unit or furnace part . . . investigate Thermalloy's heat and abrasion-resistant properties.

Thermalloy is a group of tough, heat-resistant alloys specifically developed to take heavy loads and rough usage . . . to resist corrosive gases, excessive heat (up to 2100°F.) and abrasion.

At Electro-Alloys, a competent engineering and metallurgical staff will be glad to help you utilize Thermalloy castings to best advantage in your plant. Call your nearest Electro-Alloys Office or write Electro-Alloys Division, 5002 Taylor Street, Elyria, Ohio, for complete information available in Thermalloy Bulletin T-225.

*Reg. U. S. Pat. Off.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO

As I was saying...

HERE ARE A FEW THINGS ASMers are talking about: They are happy that Assistant Secretary Ray Bayless is recovering rapidly from a major operation to relieve him from a ten-year-old case of tic douloureux ❖ they are talking about the January '54 international issue of *Metal Progress*, a great credit to the Society and to Editor Thum and his staff ❖ the energy of Taylor Lyman, publisher of *Metal Progress*, who is now, with Carl Gerlach, supervising some 30 committees preparing material for Metals Handbook supplement No. 1, to be ready soon after the middle of the year ❖ the Big Metal Show, Chicago, Nov. 1 through 5, again to put out the SRO sign for exhibits.

And ASMers are talking about the terrific interest the chapters are demonstrating in educational activities (registrations as high as 525 with attendance as high as 93%) ❖ the A.S.M. Science Achievement Awards and the swell job they are doing in interesting junior and senior high school pupils in science and engineering ❖ the completeness of Woldman's statistics covering 20,000 alloys contained in the new book "Engineering Alloys", just off the press ❖ the response of more than 10,000 members who requested copies of *Transactions*, with 1750 pages chock full of valuable engineering information ❖ the great interest in the invitation from the European metallurgical societies for joint technical meetings, plant inspections and conferences in June 1955, in London, Duesseldorf and Paris ❖ the series of lectures and laboratory operations on Metals Technology for 20 selected vocational teachers in the Southern California district conducted for the vocational department of the State of California under the direction of the A.S.M. Committee on Vocational Education (with Boston's energetic Bill Collins as chairman) and supervised by the two capable California members of the committee, Howard Farmer and Fred Robbins.

And they are talking about: President Jim Austin's excellent chapter lecture and pictures on "Magnification in Time" ❖ the tremendous advance of industry in the South where the new Jacksonville Chapter has, since its organization in September, run up a total membership of 111 ❖ how San Diego has tripled its membership in the last two years ❖ and the A.S.M. baby, Savannah River Chapter, centered in Aiken, S.C., and Augusta, Ga., will receive its charter on April 8 ❖ when will the A.S.M. have chapters in Miami, Honolulu, Mexico City and Palm Springs? (The answer: it can't come too soon to suit me) ❖ the coming appearance of the A.S.M. Secretary at the convention banquet of the National Science Teachers Association in Chicago to present awards to the winning science teachers ❖ Inland Empire Chapter's sponsorship of a Science Fair and project contest for junior and senior high school students ❖ Utah Chapter's leadership with industry in establishing engineering scholarships ❖ Chicago's turn-'em-away SRO educational course with Allis Chalmer's able Muir Frey delivering the lectures.

Also some members are talking about: the possibility of the larger chapters breaking up their membership into smaller community units ❖ the diversification of interest of the membership and the difficulty of having any six technical meetings in one season offer sufficient coverage ❖ the Secretary's presenting a paper before the American Convention Institute in January, and in spite of this, being elected to the board of trustees of the Institute in charge of the Division of Association Secretaries and Exposition Managers.

Finally, they are talking about how the Secretary drove to St. Augustine, Fla., and for 60 cents secured a glass of water from the Fountain of Youth, and, believe it or not, the next day he received a summons from his draft board!

I hope to be seeing you soon.

Cordially yours,

Bill

W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS

Solventol research has recently developed a new Series of Di-Phase Metal Cleaners which give more protection in both dip and spray cleaning operations. These improved cleaning materials now have a new high flash point minimum of 210°F. plus, making possible the following important advantages:

1. Much safer operation.
2. Less solvent loss.
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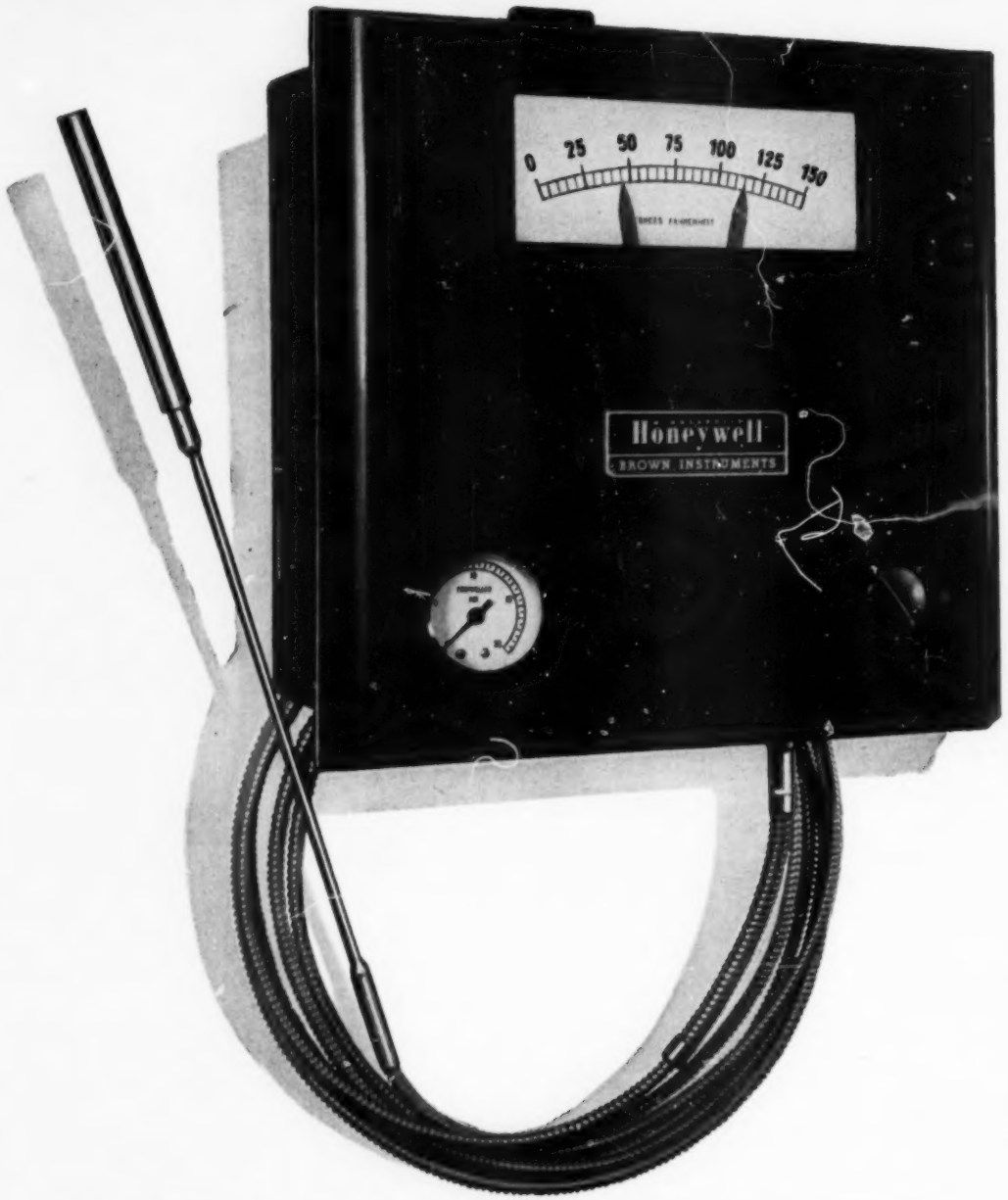

Look at these features of the Model 604P5 Thermometer Controller

GOOD READABILITY:
indicates temperature on 4½" scale.

QUICK CONTROL CHECK:
readily visible red control pointer and black indicating pointer.

CONTROL AIR CHECK:
front-mounted gauge indicates air pressure to control valve.

VARIETY OF CONTROL:
direct or reverse acting pneumatic control —either on-off or proportional action.

SELECTION OF RANGES:
23 different temperature ranges, up to 1000°F., in Fahrenheit and Centigrade calibrations, for vapor and mercury bulb systems.

COMPACT DESIGN:
die cast aluminum case 11" x 11", 4" deep; gasketed black plastic cover; practically splashproof. Interchangeable flush or surface mounting on panels of any thickness.

SIMPLE SETTING:
external knob for adjusting control point.

A new, low-cost temperature controller *from Honeywell*

MANY processes which now use manual control can utilize the advantages of automatic operation at unusually low cost—by employing the new Brown Pneumatic Thermometer Controller.

For the scores of ovens, vats, dryers and similar equipment which need only temperature indication and relatively simple control, this new instrument affords excellent control performance. It's fast, accurate . . . and simple in design. It takes so little space that it can fit readily into existing equipment or on panels.

Instrument and thermal system are complete in one package. The set point is easily adjusted by means of an external knob. The selection of control actions, ranges and types of thermometer bulbs covers literally hundreds of control applications throughout industry.

In spite of its low price, this controller is a precision-built instrument which incorporates many of the long-lasting, high-quality components used in other Honeywell products. And it's backed by Honeywell's nationwide service organization, strategically located in more than 90 principal cities of the United States and Canada.

Our local sales engineer will be glad to discuss how this new controller can be applied to your own temperature problems. Call him today . . . he is as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4503 Wayne Ave., Philadelphia 44, Pa.

● **REFERENCE DATA: Write for your copy of new Bulletin 6401.**

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First in Controls

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Now...set up in your plant...ready to produce...

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This newly announced service of the Lake Erie Engineering Corporation is not an experiment. It is something we are doing more and more for leading plants throughout industry. It is a natural outgrowth of the ever increasing desire of our customers for our specialized services. As a result, we have the resources...the staff...the experience...to offer you the complete service described at the right. Call us. Then you will fully appreciate the advantages of a central responsible source. You will not be obligated...but you will be pleased.

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General Electric Company
General Motors Corp.
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of Lake Erie production equipment including tooling

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The complete service or any part of it is available as required.

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2. We submit a detailed proposal for your review and consideration.
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5. Our field force installs or supervises the installation of the complete equipment in your plant.
6. We place the equipment in operation and train your supervisory and production personnel.
7. We assume responsibility for the satisfactory performance of the equipment as an integrated plant.

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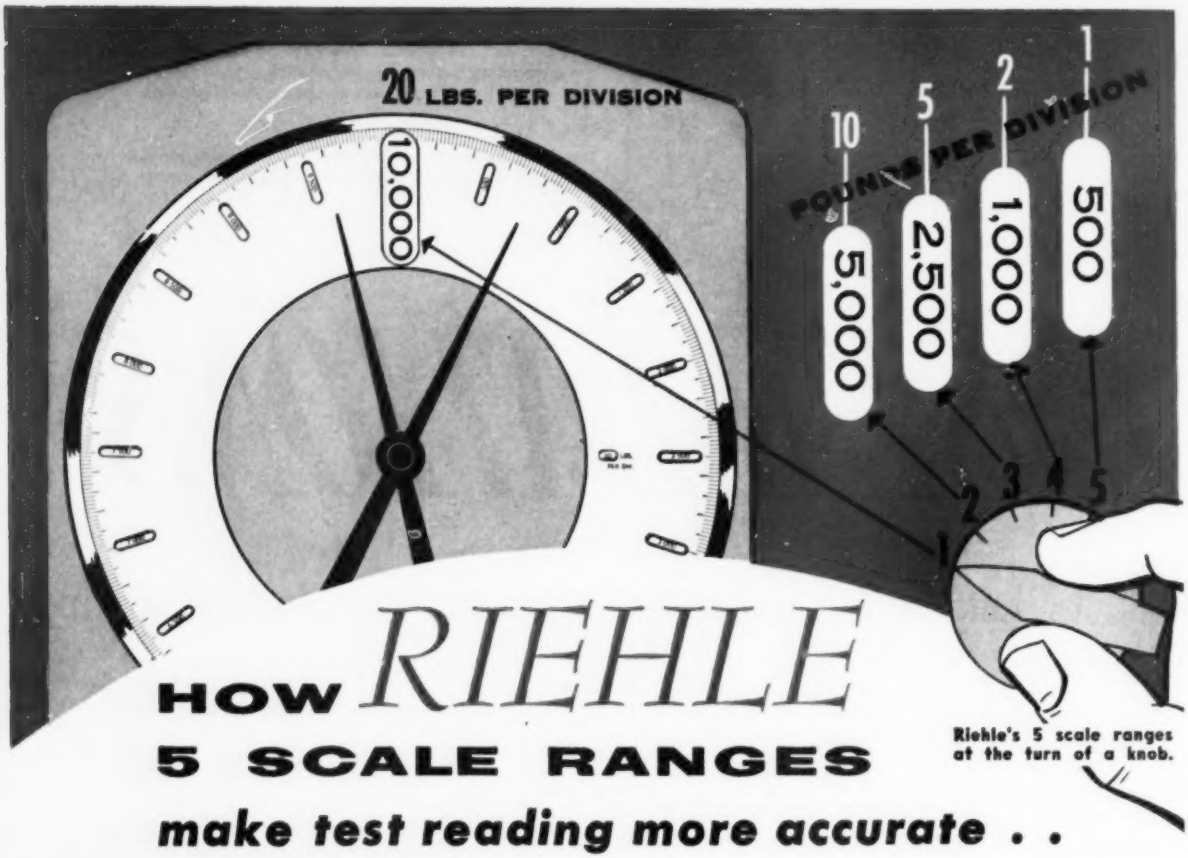
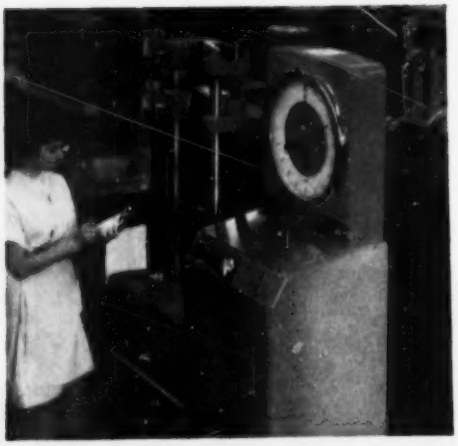


HOW RIEHLE 5 SCALE RANGES make test reading more accurate . .

Riehle's 5 scale ranges at the turn of a knob.



There's no chance for mis-reading when you're using a Riehle Pendomatic Universal Testing Machine.

On beginning a test, the operator sets Riehle's selector knob to the logical scale range. Automatically the corresponding pound load figures appear on the indicator dial. Riehle's 5-range system allows most exact interpolation by providing the fewest number of pounds per dial division. For example, when using range 5 on a 10,000 pound Riehle Pendomatic Universal, each division represents only 1 pound. This feature assures greater accuracy in reading. Also it lessens the chance for error if the operator happens to read the dial from a slight angle.

This 5 scale range dial is a *standard feature at no extra cost,* on all Riehle Pendomatic Universal Testing Machines.

Accurate to ½%, a Riehle Tester is mechanically simple, rugged and foolproof.

Riehle Universal Testing Machines are built with hydraulic or screw power loading unit. Each type is available in capacities up through 400,000 pounds. Use handy coupon to request catalogs.

Low loading table and gripping head make it easy to place specimens in a Riehle Universal Testing Machine. Its streamlined design enhances the appearance of modern testing laboratories.

• **RIEHLE TESTING MACHINES**
• **Division of American Machine and Metals, Inc.**
• **Dept. MP-354, East Moline, Illinois**

• ☐ Please send catalogs on Riehle Testers
• ☐ Send name of Riehle representative

COMPANY

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CITY ZONE STATE

NAME AND TITLE

Cleaning Concentrate

A new, noncorrosive, ferrous metal washing compound for quick, thorough removal of quenching oils after heat treating has been announced by Ipsen Industries, Inc. The new product, Compound 103, is designed for effective removal of oil, grease, lubri-

cants, soils, lapping and drawing compounds. Suitable for both batch and spray-type washers, the degreasing agent will produce metallurgically clean work pieces within 3 to 10 min. in circulating-type washing equipment. Quickly penetrating oil and grease, surface action removes and floats away impurities, and leaves parts dry, bright and clean, without residue. The degreasing agent is a fine granular mixture of alkaline materials combining detergents and surfactants. Because it is concentrated, less than 1 oz. of the washing compound per gallon of water provides an efficient degreasing solution for either batch or spray-type washers. Tank charging is simple and easy with only 18 lb. needed to charge a 250-gal. tank, as compared to 75 and 90 lb. of ordinary nonconcentrated compounds.

For further information circle No. 600 on literature request card on p. 32-B.

Beryllium Copper Strip

A new close-tolerance grade of beryllium copper strip is being supplied by Penn Precision Products. Available thicknesses run from 0.001 to 0.025 in., with minimum tolerances from ± 0.0001 to ± 0.00025 in., depending on thickness. On widths from 1/16 to 5 in., tolerances of ± 0.001 and ± 0.002 are regularly held. Emphasis is placed on solution annealing and surface conditioning, since past experience has demonstrated the importance of these operations in producing precision strip.

For further information circle No. 601 on literature request card on p. 32-B.

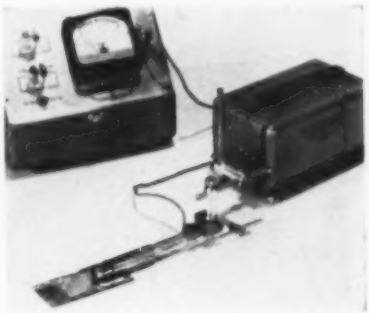
Leaded Steel

Super La-Led, a free-machining, openhearth, leaded steel bar, is now available from LaSalle Steel Co. This new bar contains about 0.25% lead and nearly 0.50% sulphur. Because it machines at speeds approaching that of brass, it has been used to replace brass on parts where corrosion is not a factor and where brass has been used because of its machinability.

For further information circle No. 602 on literature request card on p. 32-B.

Surface Roughness

Brush Electronics Co. has announced a new mechanical tracing accessory for use with the Surfindicator,

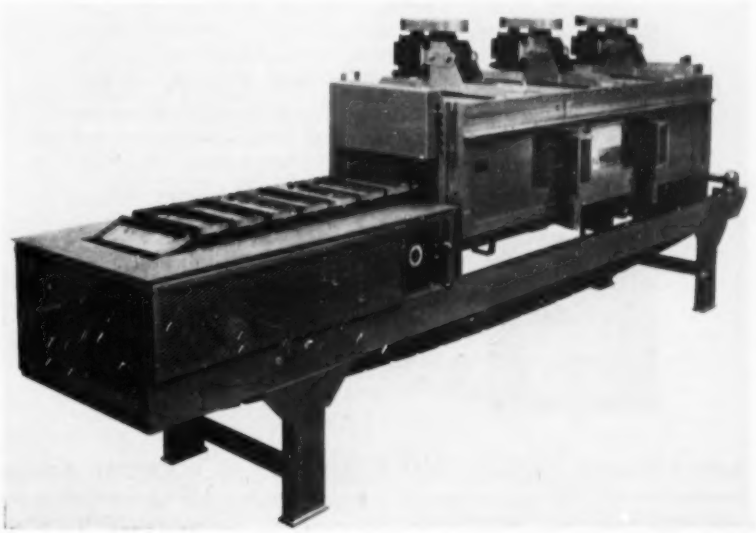


an instrument which measures surface roughness. The Brush motor drive provides mechanical movement of the

Conveyor Furnace

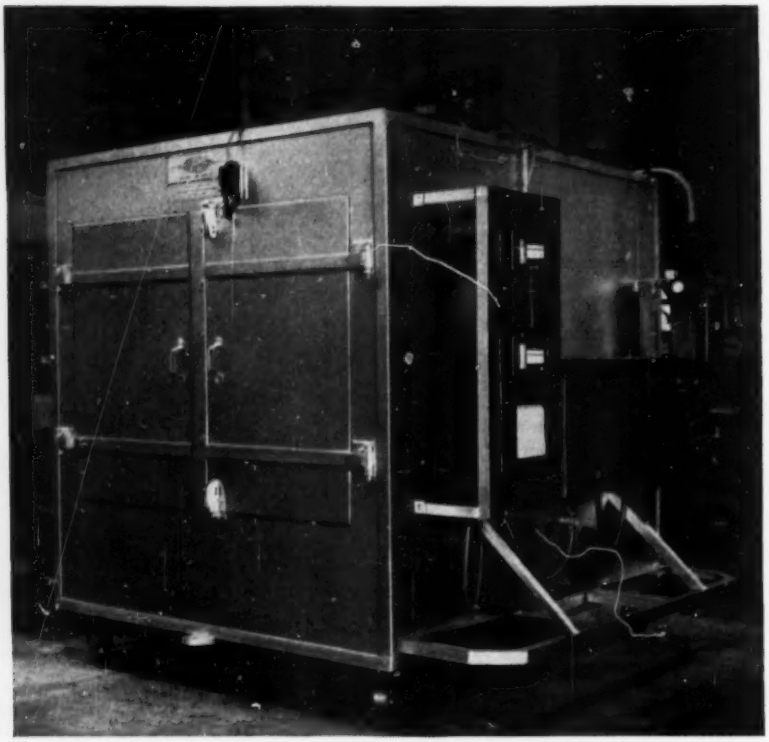
This Hevi Duty conveyor furnace was designed for heating aluminum and brass billets prior to forging. It can also be used to temper, anneal, stress relieve, or do other heating operations requiring a maximum temperature of 1650° F. Elements are of nickel-chromium wire wound through ceramic refractories. Three fans speed heating by circulating the heated air. Trays are designed so small parts will pass through the furnace without falling off the conveyor. A variable speed drive mechanism adjusts the conveyor speed so that parts can remain in the furnace chamber from 13 min. to 2 hr., 10 min. Tanks and trays are of heat resistant alloy.

For further information circle No. 603 on literature request card on p. 32-B.



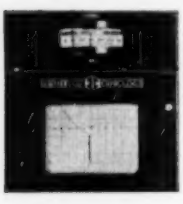
BARBER COLMAN

Wheelco Recorder-Controllers



control temperatures and costs on MORRISON electric ovens

These portable electric ovens, built by Morrison Engineering Corporation, Cleveland, Ohio, are equipped with Wheelco Capacilogs for accurate indication, control and permanent record of stress-relieving operations. For low-cost operation with furnaces, ovens, kilns, and other heating equipment, the Capacilog eliminates troublesome service and maintenance problems. With plug-in assemblies, simple and easy to adjust . . . with economical periodic service from Wheelco's nationwide engineering staff . . . your instrument worries are over when you standardize on Wheelco Capacilogs. Read about Capacilog simplicity and accuracy in Bulletin C2-2.



Modern design . . . electronic principle!

Electronically operated, Capacilogs give you fast, simple, precise control and permanent record of heating operations—assure closer temperature control and greater product uniformity. Save time and fuel, easy to service and maintain.

BARBER-COLMAN COMPANY, DEPT. C, 1518 ROCK ST., ROCKFORD, ILLINOIS

Industrial Instruments • Automatic Controls • Air Distribution Products • Aircraft Controls • Small Motors
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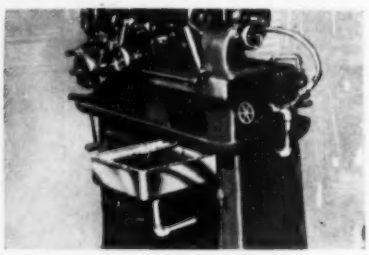
pickup along a surface being inspected. It is designed for special applications which extend the usefulness of the basic instrument beyond the range that is practical with hand operation. It has a reciprocating stroke whose length is adjustable from 2⅞ to less than 1/16 in., allowing for an extremely wide range of measurements. Stroke speed is ⅛ in. per sec. Instantaneous reversal, constant speed, and low vibration level of the unit insure accurate surface roughness measurements.

For further information circle No. 604 on literature request card on p. 32-B.

Coolant Filter

The Delpark Junior, a positive-action filter for low coolant flow, has been announced by the Industrial Filtration Co. Continuous positive filtration removes abrasive solids from the work. Savings are effected in



meeting rigid tolerances and finishes, in greater production through machine efficiency and fewer rejects. The new filter comes complete with combination mounting bracket and clean coolant return line or, if preferred, a connection is available for separate pipe or hose. A woven wire basket holds the disposable filter tray. When a tray becomes so filled with swarf that it will no longer take the flow of coolant, it is easily removed and replaced with a new one.

For further information circle No. 605 on literature request card on p. 32-B.

Opaque Silica

Quartz Products Corp. has announced a new line of opaque silica rod and tubing of various diameters and wall thicknesses. By means of

new manufacturing processes these items can now be supplied with regular shapes, precise tolerances and thoroughly glazed surfaces. The super-smooth surface and great uni-

formity are most important characteristics in minimizing devitrification at high temperatures. Precise tolerances as to bore and wall thickness offer the opportunity of using opaque silica for many new uses which could not be considered prior to now.

For further information circle No. 606 on literature request card on p. 32-B.

Testing Cable and Wire

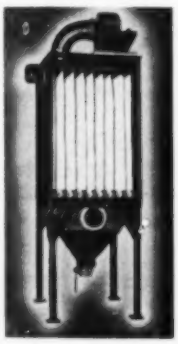
A new tester for prestretching and proof-testing aircraft cable and other wire assemblies has been announced by Riehle Testing Machines Div. The

new 6500-lb. capacity multiple cable and wire tester tests five different sizes of cable simultaneously. Built with five separate tensioning units, all with different ranges, each unit can be preset to exert any load within its range, for any period from 3 sec. to 20 min.

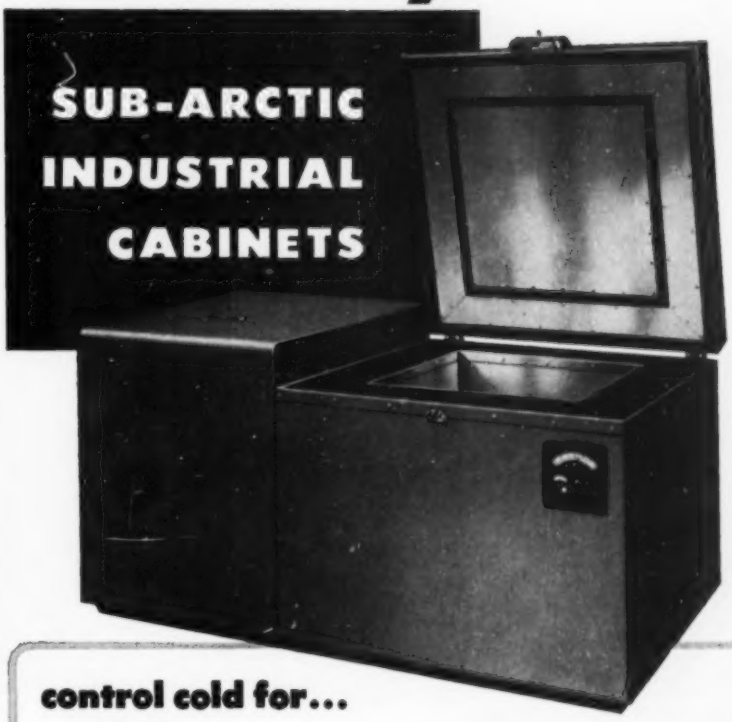
For further information circle No. 607 on literature request card on p. 32-B.

Dust Collector

A new unit-type CN cloth bag collector, designed for economical and efficient dust collection for smaller volume applications, has been announced by Pangborn Corp. Each unit is self contained and shipped assembled, ready for installation. It is designed for indoor use and clean air can frequently be discharged inside the plant — a distinct saving where air is heated or cooled. Finely divided dusts such as carbon black, cork, fine wood, graphite, pigments, lime, lamp black, soap, and metal oxides, are collected through



Tenney



control cold for...

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Viscosity
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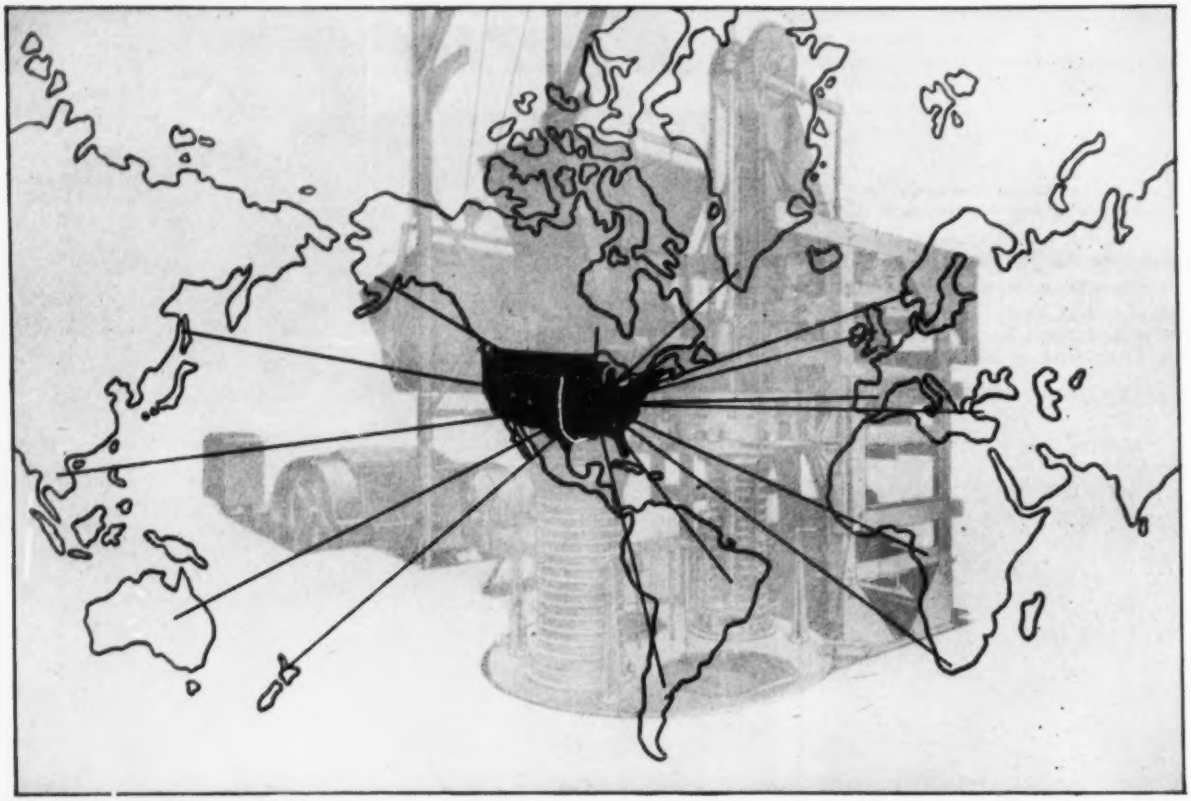
of Chemicals, Biologicals, and Serums

Tenney Sub-Arctic Industrial Cabinets are adaptable to all these important applications—wherever low temperature refrigeration with constant control, rapid pull-down, reliability of operation, and minimum maintenance are essential to operations. There are 28 models available in standard and special units in 1, 4, 6, 9, and 12-cu. ft. capacities, either air- or water-cooled. And for low temperature points, there is a range of six ratings: −40, −80, −100, −120, −150, and −170° F.

For features, specifications, and optional equipment, write for Sub-Arctic Bulletin.

Tenney
ENGINEERING, INC.

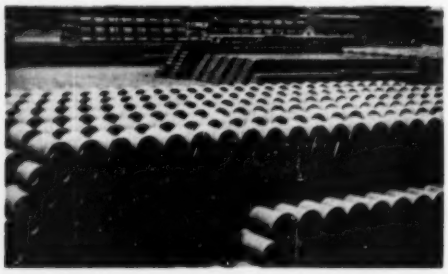
Dept. ME, 1090 Springfield Rd., Union, N. J.
Plants: Union, N. J.; Newark, N. J.; Baltimore, Md.
Los Angeles Representative: George Thorson & Co.
Engineers and Manufacturers of Automatic Environmental Test Equipment



From Sioux City, Iowa:

CITIES SERVICE OILS AND GREASES SENT ALL OVER THE WORLD WITH McCRACKEN MACHINES!

"**OUR FINISHED MACHINES** are completely serviced with Pacemaker 2 hydraulic fluid, Optimus 4 oil in the transmission and Trojan M for bearing grease."



CORRUGATED CONCRETE PIPES, used for sewer, culvert and irrigation work, are one of industry's most vital tools. McCracken Machines make the very finest.

ONE CITIES SERVICE PRODUCT SOLD MANUFACTURER ON THE COMPLETE CITIES SERVICE QUALITY LINE!

During the early part of World War II, Concrete Pipe Machinery Co., manufacturers of McCracken Machines, called in a Cities Service Lubrication Engineer for answers to some tough metal-cutting problems. On his recommendation, they tried Cities Service Cutting Oil, Chillo 93. Finished work was so improved and tool life so prolonged, that Concrete Pipe had a complete lubrication survey made of their plant.

THIS CAREFUL SURVEY PROVED THAT THE COMPLETE CITIES SERVICE LINE COULD DO THE BEST JOB FOR THEM. Electric motors, spindles, gear reducers, air compressors . . . drilling, grinding, machining of cast iron parts, threading, tool and die work . . . hydraulic systems, bearings, transmissions . . . Cities Service Industrial Oils, Greases and Cutting Oils did better on every job! Concrete Pipe Machinery Co. says: "They are giving us outstanding service, and availability and delivery have always been excellent."

If you'd like to talk to a Cities Service Lubrication Engineer, write Cities Service Oil Company, Sixty Wall Tower, New York 5, New York, or call the office nearest you.

CITIES SERVICE

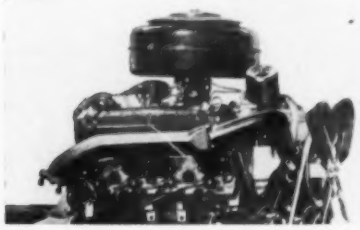
QUALITY PETROLEUM PRODUCTS

cloth filter bags similar to the large Pangborn dust collector. Dust laden air enters the collector where it is expanded in a settling chamber. Here, the reduction in velocity drops coarser dust particles directly into the hopper. A baffle plate prevents the air from rising immediately to the cloth bags, and therefore the only escape for air is through the open bottom of the bags. This air then flows into the bags where the fine dust particles are filtered on the bags' inner surfaces. Cleaned air passes through the bags and is discharged from the collector.

For further information circle No. 608 on literature request card on p. 32-B.

Heat Resistant Finish

For the second straight year the exhaust manifold of the Lincoln car features the protection of Sicon, a sili-

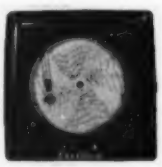


cone-base heat resistant finish supplied by the Midland Industrial Finishes Co. Sicon is used to protect the surface against unsightly dulling, film deterioration and corrosion. It was first tested under temperatures of 1000° F., substantially more severe than is ever encountered under maximum operating temperatures. Black and other colors are available.

For further information circle No. 609 on literature request card on p. 32-B.

Multipoint Recording

Fielden Instrument Div., Robertshaw-Fulton Controls Co., has announced a new approach in multipoint recording through two new models. Capable of gathering operating data from 24 separate sources and logging the collective information on a single circular chart, both models will provide accurate measurement for a wide range of industrial process and laboratory applications. The instruments can be directly coupled to resistance thermometers, conductivity cells, strain gages, carbon dioxide indicators, pH meters, and other devices to produce a permanent record of operating variables. In a number of industrial applications a single recorder will adequately take care of every recording requirement. Recording is achieved through a unique six-point turret pen mechanism which traces six different colors. By dividing the standard circular chart into four equal parts and installing a mechanism to rotate the chart periodically, data from six separate points can be logged in each quarter. The print cycle is 5 sec. per point and the total cycle for all 24 points is only 2 min. A convenient feature never before offered in any other multipoint recorder allows the cycling mechanism to be switched off, permitting the unit to operate as a standard single-point pen inking recorder.

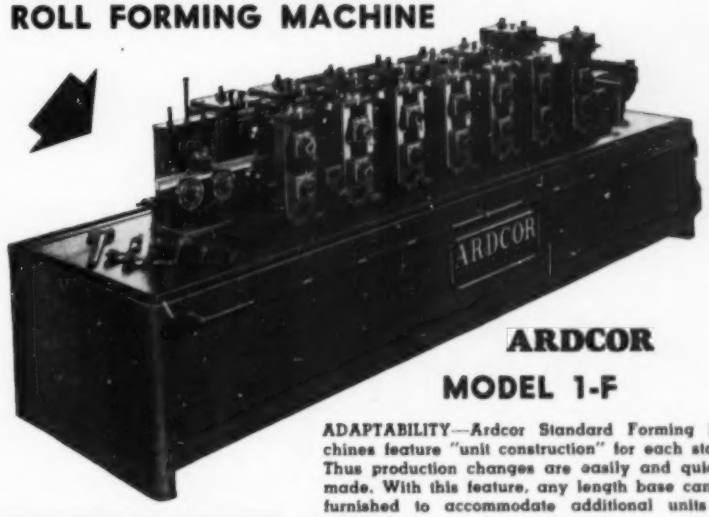


For further information circle No. 610 on literature request card on p. 32-B.

Fatigue Testing

Fatigue-testing machines that give rapid, accurate results on large components are now being introduced into the United States for the first time after many years of successful use on the European continent and in Great Britain. Built by Losenhausenwerk A.G., leading German manufacturers of mechanical test equipment, the machines are distributed in the U.S. by

The Production-WISE
ROLL FORMING MACHINE



ARDCOR
MODEL 1-F

Spindle Diameter	1½"
Roll Diameter	4¼" to 7"
Horizontal Distance Between Spindles	12"
Roll Space on Standard Machine	10"
Capacity Max.	.072

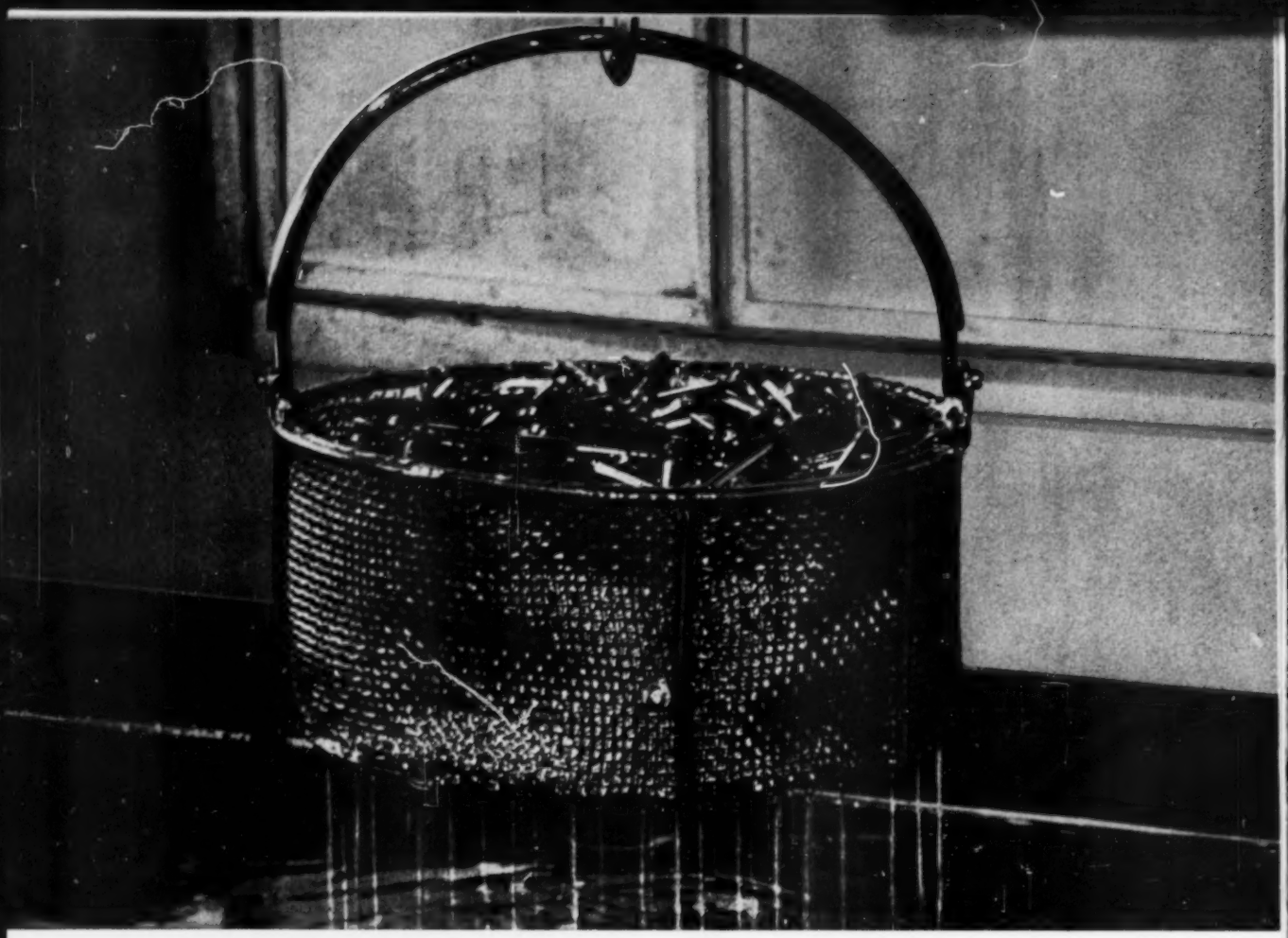
ADAPTABILITY—Ardcor Standard Forming Machines feature "unit construction" for each stand. Thus production changes are easily and quickly made. With this feature, any length base can be furnished to accommodate additional units as required.

Ardcor Roll Forming machines embody the precision, accuracy and stability found only in the highest grade machine tools. In addition, Ardcor offers a completely engineered installation—cradle reels, roll forming machines, roller dies, flying cut-off fixtures, etc.—from one qualified source.

Likely as not your special shapes can be ideally handled by a standard Ardcor machine. Your inquiry is invited—without obligation.

Also Standard Machines up to 4½" Spindle Diameter.

American ROLLER DIE CORPORATION
29551 Clayton • Wickliffe, Ohio



You Get Minimum Drag-out with Sun Quenching Oil Light

When you reduce oil consumption by lowering drag-out, you cut a major cost in operating a quenching system. Sun Quenching Oil Light thins out when heated, drains off parts faster and more completely. And Sun Quenching Oil Light, because of its natural detergency, prevents the formation of sludge deposits, aids in removing any deposits that have accumulated. And under normal operating conditions it need never be replaced. Sun's booklet "Sun Quenching Oils" tells about this low-cost oil. For a copy, call your nearest Sun office or write SUN OIL COMPANY, Philadelphia 3, Pa., Dept. MP-3.

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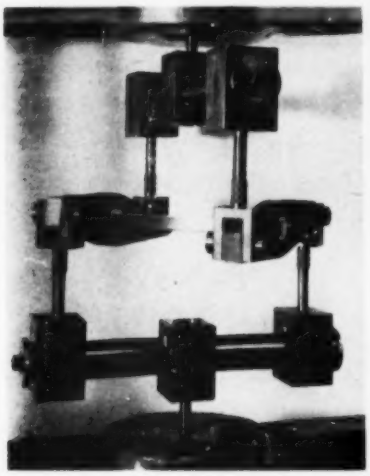
Kurt Orban Co. The Losenhausen fatigue-testing machines, which are expected to be of special interest to the American aircraft industry, provide for tensile, compression and bending tests under static fluctuating and alternating dynamic loads. The largest standard size exerts a 200-ton static and a 100-ton dynamic load. Outstanding feature of the machines is a pulsator for the hydraulic production of pulsating forces at any one of four frequencies. This pulsator can also be attached to standard Losenhausen static testing machines to adapt these machines to dynamic tests under fluctuating loads. In addition, the pulsator can be used with specially designed individual testing cylinders for static and dynamic loading of airplane wings and other structures.

For further information circle No. 611 on literature request card on p. 32-B.

Torsion Test

To produce pure torsion on a tension testing machine, Baldwin-Lima-Hamilton Corp. has announced the Schaevitz torsion device. Test specimens up to ¾ in. square and ranging



from 2 to 12 in. long (plus 2 in. to be engaged by torque bars) can be twisted to a maximum angle of 24 deg. Maximum torque load is 60,000 in.-lb., obtained by applying a 12,000-lb. tension load. The new Schaevitz torsion device is furnished with hardened socket liners for specimens ⅜, ½, ⅝, and ¾ in. square or for round specimens with square ends of these sizes. Ends of test specimens are secured in the centers of two parallel torque bars. Torque bars are rotated in opposite directions by means of four tension members that are pivotally connected in the ends of two equalizer bars. Pivotal connections are provided also for the two spherically-headed tension rods that are seated in wedge block adapters in the testing machine crossheads.

For further information circle No. 612 on literature request card on p. 32-B.

Gold Plating

All of the necessary equipment for mass production plating of precious metals or small-scale laboratory pilot plant operation is combined in the new portable Jet Plater by Sel-Rex Precious Metals, Inc. Also incorporated in the new unit is a unique "jet" agitation action, making it available for the first time in any small-volume plating unit. Designed for high-speed plating with the new Sel-Rex bright gold process and bright silver bath, the unit can also be furnished with a rubber-lined or koroseal tank for use with acid solutions. Completely automatic in operation, the plater consists of a selenium rectifier with an automatic timer, of the proper output rating for tank size; a stainless steel tank, which can be used as the anode, with a water compartment for temperature control; a movable work rack, which will accommodate a portable plating barrel; a corrosion resistant, stainless steel filter; a polyethylene, drip-proof pump powered with a ¼-

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. . . AND HERE'S WHAT IT MEANS TO YOU:
It means POSITIVE REGISTRATION at the shear point—at the first stroke and at the millionth . . . and DIES LAST LONGER.
It means LOW FRICTION die set operation, eliminating galling of pins . . . speeding production.
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BALL BEARING DIE SETS
LEMPCO PRODUCTS, Inc., Industrial Division . . . Bedford, Ohio

New CMP INDIANAPOLIS PLANT

This new additional plant of The Cold Metal Products Co. completes another step in the CMP expansion program. It's a special plant because it is technically engineered and equipped for the specialized production of the particular types of cold rolled strip and spring steel most needed by CMP customers in the mid-west area easily served from the Indianapolis location.

CONSTRUCTION

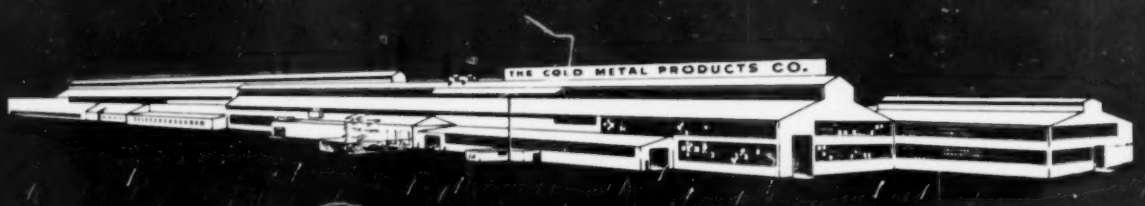
Constructed along lines of today's clean simplicity of structural design, it provides for the most efficient flow of material in process to net the lowest manufacturing cost practical for the special tolerances, structures and finishes characteristic of CMP strip and spring steel products.

FACILITIES

Included are CMP-Type designed and built 4-High cold rolling mills, annealing furnaces, slitters, pickle line and auxiliary equipment necessary to produce the high standard of quality generally identified with CMP strip and spring steel products.

LOCATION

On a 32 acre site at 2301 South Holt Road in suburban Indianapolis, CMP is the first company to recognize and provide for the steadily growing needs of the area as an important consumer of specialized flat rolled steel products.



YOUNGSTOWN PLANT AND GENERAL OFFICE

A COMPLETELY *NEW* PLANT . . .

FOR ADDITIONAL CMP PRECISION COLD ROLLED STRIP STEEL PRODUCTION

With the additional Indianapolis facilities now in operation and providing an increased tonnage of CMP strip all customers will benefit. Since more product will be produced more customers can be served and improved deliveries in all areas will result.

The fact that so many fabricators have turned to CMP for the cost saving and product improving advantages of "special spec" cold rolled strip and spring steel is forceful testimony to the importance of spending more time in checking the values CMP products can offer you.

THINSTEEL
TRADE MARK

STILL PIONEERING, STILL IMPROVING COLD ROLLED STRIP AND SPRING STEEL PROCESSING FOR IMPORTANT FABRICATION AND END PRODUCT ADVANTAGES

C M P

MUELLER BRASS CO.

600 SERIES BEARING ALLOYS

FORGINGS • ROD • SCREW MACHINE PRODUCTS

proving their quality throughout American industry

Mueller Brass Co. "600" series bearing bronzes are lightweight, high strength copper-zinc base alloys with excellent bearing and mechanical properties, non-galling and non-seizing characteristics and good resistance to corrosion. They have a dense, homogeneous structure that reduces machining time and metal waste and increases tool life. As bearings, gears, connecting rods, cams and other parts, they will generally save you considerable money and outperform and outlast the cast phosphor bronzes. Write today for complete information about the MUELLER BRASS CO. "600" series alloys for forgings, rod or screw machine products.

six members of "600" series . . . one for every purpose

There are six members in the "600" series group, and they possess fundamentally similar characteristics. But slight differences in the properties of each are produced through variations in the basic formula. Thus, each metal is best suited to perform a specific set of functions. And as a group, they are suitable for a wide range of applications.

119

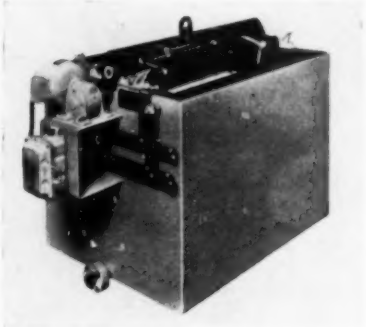
MUELLER BRASS CO. PORT HURON 20, MICHIGAN

hp. motor; and a "safety" tank under the plating tank, pump and filter to catch leakage or accidental spillage.

For further information circle No. 613 on literature request card on p. 32-B.

Plating Tank

Hanson-Van Winkle-Munning Co. has announced an improved Mercil-type tank for barrel electroplating. The new tank is designed to save space, reduce maintenance cost and simplify barrel-positioning. With the exception of chrome plating, any type of plating may be carried out in the new tank. Improvements are: (*a*) flanges have been turned in, saving space and providing an enclosure for



hanging heating or cooling coils, (*b*) motor drive has been made more compact and relocated, with the drive shaft now located above solution level, (*c*) saddles have been redesigned to permit operator to guide the barrel into position more easily, (*d*) an overflow trough is not needed and has been eliminated, and (*e*) the hanger assembly has been improved to assure proper alignment of the cylinder and gears.

For further information circle No. 614 on literature request card on p. 32-B.

Slab Heating

A new type of slab heating furnace which can heat up to 70 tons per hr. of stainless steel, silicon (electrical quality) steel or carbon steel from room temperature to 2275° F. has been designed and erected by Salem-Brosius, Inc., for Allegheny Ludlum's Brackenridge plant. It heats slabs from 5 to 9 in. thick in lengths up to 17 ft., 3 in. This pusher-type furnace differs from conventional slab heaters in that heat is applied through burner ports located along the sides and at the discharge end of the furnace, rather than just through the discharge end. This makes possible faster, more uniform heating. Slabs are charged sideways in a continuous line through the furnace chamber. As each new slab is pushed into the furnace,

a conditioned slab is discharged for rolling or further processing. The furnace is 107 ft. long and can be fired with either gas or oil.

For further information circle No. 615 on literature request card on p. 32-B.

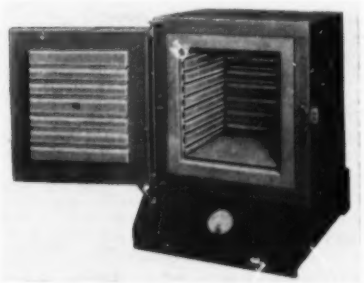
Hardness Tester

A production model, direct-reading Brinell hardness testing machine, designed to fit directly into a conveyor system, is announced by Steel City Testing Machines, Inc. Highlight of the new design is a roller conveyor arranged in conjunction with the anvil of the tester. The anvil itself consists of a series of hardened steel bars. Between these bars are interspersed the rollers of the conveyor, which are lowered and raised by momentarily depressing the knee switch allowing the part to come to rest on the anvil bars. Then the ball penetrator automatically lowers, applying the load and making the Brinell impression, after which the penetrator rises, the roller conveyor rises, and the operator rolls the part off the machine onto another matching conveyor which carries it on to the next operation.

For further information circle No. 616 on literature request card on p. 32-B.

Furnace

L and L Mfg. Co. has introduced a new line of electric furnaces, designed to reproduce any time-temperature curve within ±3° F. in the range up to 2300° F. Because of their stability, they have been used for calibration and instrumentation. Infinite zone control by means of input controllers controls from 8% to 100% of input. Once the furnace has reached the desired temperature level (between 500 and 2300° F.), it can be maintained to a ±3° F. Compensation for line voltage fluctuation is automatic.



For further information circle No. 617 on literature request card on p. 32-B.

NEW ADVANCE IN QUANTOMETRY

ARL Industrial Research Quantometer Shows New Versatility

Greatly Improved IRQ* Hailed As Most Flexible Direct-Reading Instrument Available

The new, flexible IRQ provides industrial laboratories with a means of quantitatively measuring a large number of elements simultaneously in a few minutes. It thus allows analytical research and control heretofore considered impossible. By incorporating movable and fixed receivers, any of the elements amenable to spectrochemical analysis can be measured with complete flexibility as to choice and order and with little restriction as to number. This versatility of the IRQ permits high speed analysis of all types of materials. For example, the unit is capable of giving an accurate chemical analysis of such widely diversified materials as high and low alloy steels, pig or cast irons, aluminum, zinc, lead and copper base alloys, minerals, ores and biological and pharmaceutical substances.

Automatic pen recording provides duplicate copies of the analyses on direct-reading charts during the few minutes required to complete the operation.

A unitized type of construction provides great accessibility and serviceability and allows quick changes to be made in the elements, the concentrational ranges, and the recording order of interest.

The speed, accuracy and flexibility of the IRQ makes it a "must" for every really well-equipped laboratory. Under actual operation, it will quickly return its cost by extending analytical research and control at greatly reduced expense.

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Trade Mark — The ARL line includes Production Control Quantometers, 1.5 and 2-meter Spectrographs, Precision Source Units, Raman Spectrographs and related accessories.

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Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM TOOL STEEL ENGINEER SAYS:

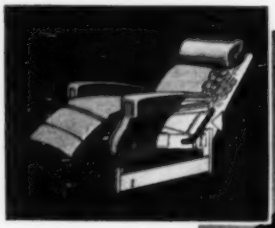
Pack-hardening Tools? It's Best to Use a Thermocouple

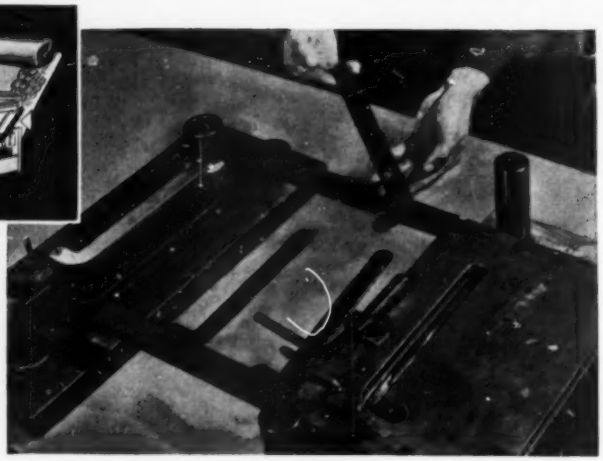
In shops which do not have controlled-atmosphere furnaces, you will sometimes find it desirable to pack-harden the tools, so as to avoid both excessive scaling and decarburization.

This can be accomplished by packing the tools in sealed containers prior to charging in the furnace, using protective materials such as cast-iron chips, wood charcoal, or spent carburizing compound. However, in following this procedure, this precaution is important: do not permit any of the tools to come in contact with the container.

Heating through the pack is a slow process at best, and for this reason it is often difficult to make a close estimate of the length of time required for proper heating. We therefore recommend that a thermocouple be inserted in the pack, close to the tools.

After the tools have been heated the proper length of time, they may be removed from the pack, then quenched in the usual manner. If a controlled-atmosphere furnace is not available, pack-hardening should always be used on those steels which have a quenching temperature in excess of 1650 F. This does not hold true, however, in the case of high-speed and hot-work steels.





Inset (above) shows type of chair in which back hinge is used. The BTR die, together with the hinge, is shown at right.

BTR BLANKING DIE MAKES PART FOR MECHANISM OF BARCALOUNGER CHAIR

At the busy plant of Barcalo Manufacturing Co., Buffalo, N. Y., they're turning out, among other things, a back hinge which is used in the tilting mechanism of the popular Barcalounger chair.

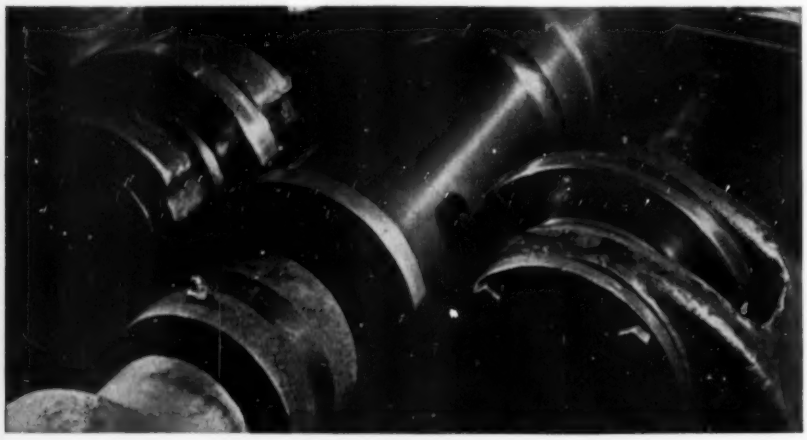
The operation, performed by a blanking die in a 200-ton press, involves two steps—punching five small-diameter holes in 3/16-in. sheet steel, then blanking the hinge to size. The die, made of BTR, is hardened to Rockwell C58-60. It is giving a good account of itself because of its resistance to the shock encountered. And as for wear, the die is expected to last and last, for with 6000 pieces produced daily, its use is required only periodically.

BTR (Bethlehem Tool Room) is our manganese-chromium-tungsten grade of oil-hardening tool steel, well known for its safe-hardening property.

Typical Analysis:

Carbon	0.90	Vanadium	0.20
Manganese	1.20	Tungsten	0.50
	Chromium 0.50		

If you have a job calling for a safer hardening steel than carbon tool steel—such applications, say, as blanking, cold-forming, and bending dies, forming rolls and the like—it's hard to beat BTR.



Lehigh S Increases Life of Burnishing Rolls

This picture shows the burnishing of a freight car axle to provide a smooth, mirror finish. Two rolls, at right angles to the work and applied with about 400 psi pressure, cold-roll the axle simultaneously. The rolls are made of Lehigh S (our oil-hardening type of high-carbon, high-chromium tool steel), hardened to Rockwell C-62. They burnish 60 axles in 8 hours, and have a service life of about six months. With grades formerly used, the maximum service life was two months.

WHAT'S NEW IN MANUFACTURERS' LITERATURE

641. Air-Gas Mixer
Bulletin L-700 gives engineering and application data on air-gas proportional mixer. *Eclipse Fuel Eng'g*

642. Alloy Hearth
Bulletin 112 on cast Ni-Cr hearth for heat treating furnaces. *Fahralloy*

643. Alloy Steel
16-page book on type 9115 low-alloy high-strength steel. Properties, fabrication, welding. *Great Lakes Steel*

644. Alloy Steel
Data book on the selection of the proper alloy steel grades for each manufacturer's needs. *Wheelock, Lovejoy*

645. Aluminum Extrusions
28-page book on extruded aluminum products. Design, tolerances, applications. *Revere*

646. Aluminum Extrusions
Data on services in the field of aluminum extrusions. *Himmel Bros. Co.*

647. Aluminum Heat Treating
8-page Bulletin 5912 on solution heat treating, annealing, stabilizing and aging of aluminum. *General Electric*

648. Aluminum Strip
20-page book gives technical data on five grades of aluminum strip. *Scovill*

649. Ammonia
18-page booklet on ammonia and its uses and ammonia installations for metal treating. *Armour Ammonia*

650. Ammonia Dissociators
Bulletin on dissociating process gives advantages of ammonia as controlled atmosphere. *Sargeant & Wilbur.*

651. Analysis of Nickel Alloys
52-page Technical Bulletin T-36, "Methods for Chemical Analysis of Nickel and High-Nickel Alloys." *International Nickel*

652. Annealing
Experience at Johns-Manville with atmosphere furnace for annealing gaskets and miscellaneous parts. *Sunbeam*

653. Atmosphere Control
Bulletin No. AD-609 on providing an inert, oxygen-free furnace atmosphere through proper instrumentation and procedure. *Arnold O. Beckman*

654. Atmosphere Furnace
Reprint on bright annealing of copper in atmosphere furnace. *Holcroft*

655. Atmosphere Furnace
Bulletin on controlled atmosphere furnace. *Industrial Heating Equipment*

656. Atmosphere Furnace
Information on mechanized batch-type atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

657. Atmospheres
Bulletin 1-10 supplies technical information on inert gas generators and data on costs. *C. M. Kemp Mfg.*

658. Atmospheres
8-page Bulletin SC-155 discusses following controlled atmospheres: RX, DX, NX, HNX, AX, HX. Compositions, applications, effects on steel, drawings of generators. *Surface Combustion*

659. Balances
Bulletin No. 329 on precision balances with projection readings. *Burrell*

660. Bar and Tube Turners
16-page bulletin on centerless turners for round bars and tubes. *Medart*

661. Barrel Finishing
32-page handbook on compounds for descaling, deburring, coloring, metal cleaning and rust inhibition. *Lord Chemical*

668. Blackening Compounds
Bulletin on blackening compounds for ferrous alloys to AMS Spec. 2485. *Swift Industrial Chemical*

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Bulletin of operating instructions for blackening and coloring copper and copper alloys. *Enthone*

670. Blast Cleaning
24-page Bulletin 400 on blast cleaning installations for large work. *Pangborn*

671. Blowers
Bulletin 100-53 on combustion air blowers of 8 to 20 oz. pressures. *Western Products*

672. Boron Additive
6-page article on use of grainal as boron-additive alloy and properties of grainal steels. *Vanadium Corp.*

673. Brass
Bulletin B-39 on Formbrite drawing and forming brass. *American Brass*

674. Brass Foundry
Article discusses sand in the brass foundry. *Lavin*

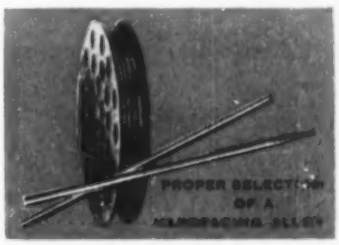
640. Hardfacing Alloys

This 48-page book covers the use of hardfacing alloys systematically, in three ways: by properties, by alloys and by applications.

Properties. Wear resistance is determined by six factors: hardness, impact resistance, abrasion resistance, friction, heat resistance and structure. Under each of these property headings, comparative data are given for the different hardfacing alloys. The data are directly related to selection.

Alloys. A data sheet is given for each of twenty hardfacing alloys, including austenitic manganese steels, martensitic steels, stainless steels, cobalt-chromium base alloys, cast irons, and tungsten carbide. Type of service and typical applications are included along with property data for each material.

Applications. About 700 specific items are listed and opposite each



is given the alloy or alloys recommended for that application. The list is broken down according to industry (automotive, foundries, steel producing, machinery, etc.) with the pertinent applications given alphabetically under each.

*Published by American Manganese Steel Div., American Brake Shoe Co. Copies are available at no charge to readers of Metal Progress who circle No. 640 on the literature request card, page 32B.

662. Belt Polishing
Bulletin gives case histories of backstand-belt polishing. *Coated Abrasives Div., Armour & Co.*

663. Bending
28-page booklet on tangent bending machines, some products made on them and processes used. *Cyril Bath*

664. Bending and Cutting
Folder describes hand and air-operated bender-cutter and its applications. *J. A. Richards*

665. Beryllium Copper
16-page booklet on applications and properties of beryllium copper. *Beryllium Corp.*

666. Black Oxide Coatings
Data on black oxide coatings for steel, stainless steel and copper alloys. *Du-Lite*

667. Black Oxide Finish
Bulletin H-16 on blackening salt. *Park Chemical*

675. Brazed Tubing
12-page data book on brazed tubing made from copper-coated steel. *Bundy*

676. Brazing
Bulletin 124—on salt bath brazing process—shows how it is possible to substitute brass for copper and develop joints of adequate strength. *Ajax Electric*

677. Bright Carburizing
Job data on bright carburizing and hardening gears. *Ipsen*

678. Burners
Bulletin on combination gas and oil burner. *Ra-Diant Products*

679. Carbide Coatings
12-page Bulletin 8065, "Flame Plating," on method of applying tungsten carbide coatings. Comparative wear test data. Applications. *Linde*

680. Carbon and Graphite
20-page catalog on carbon and graphite

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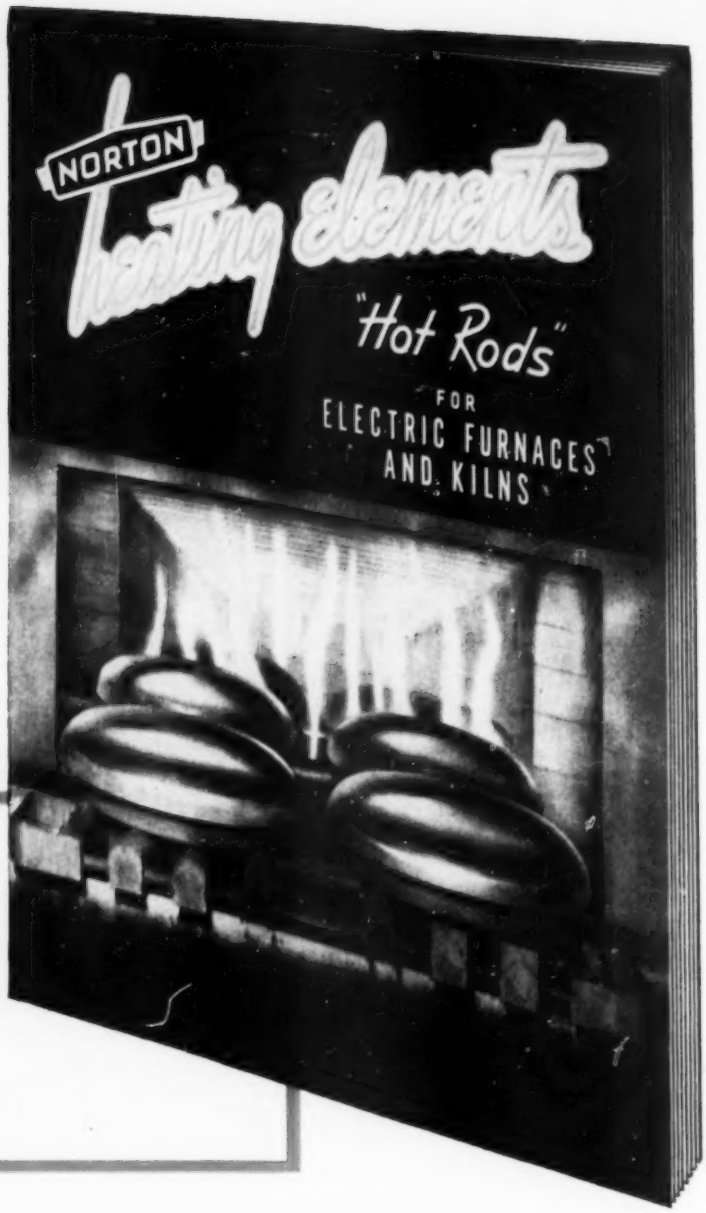

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applications in metallurgical, electrical, chemical, process fields. *National Carbon*

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Bulletin 241 on gas-fired radiant-tube furnace for carbonitriding and other heat treating. *Lindberg Engineering*

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Literature on Ni-Carb (carbonitriding) treatment for surface hardening. *American Gas Furnace*

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Booklet on spun centrifugal castings of bronze for liners, rings, rolls, sleeves, bushings. *American Non-Gran Bronze*

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695. Cleaning Aluminum
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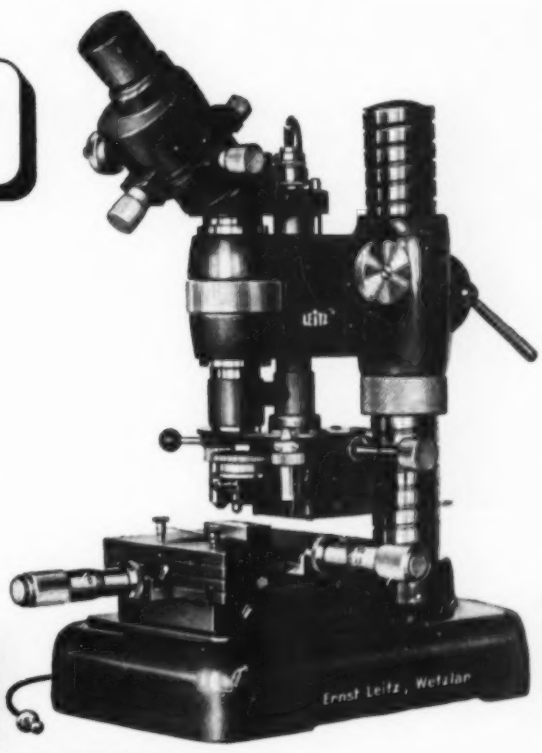

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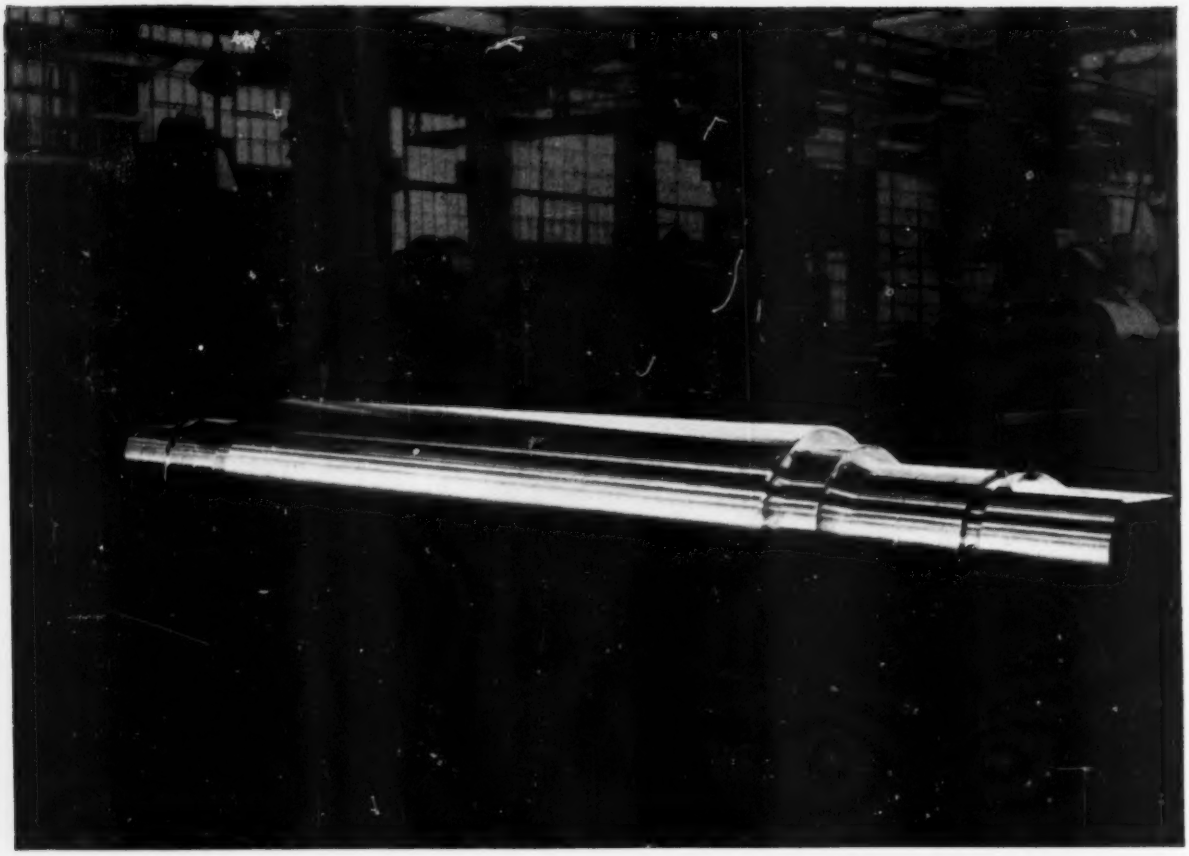

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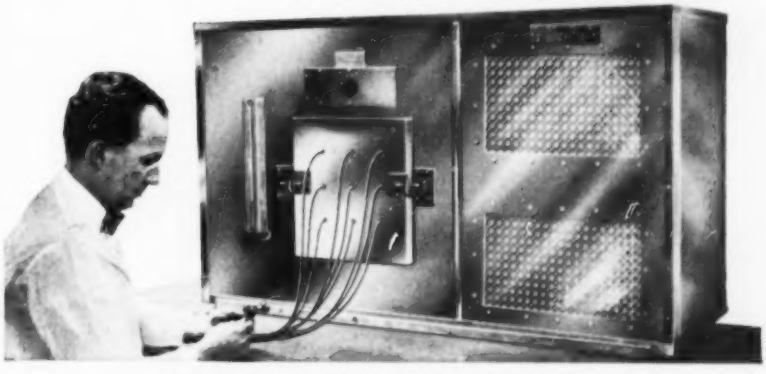

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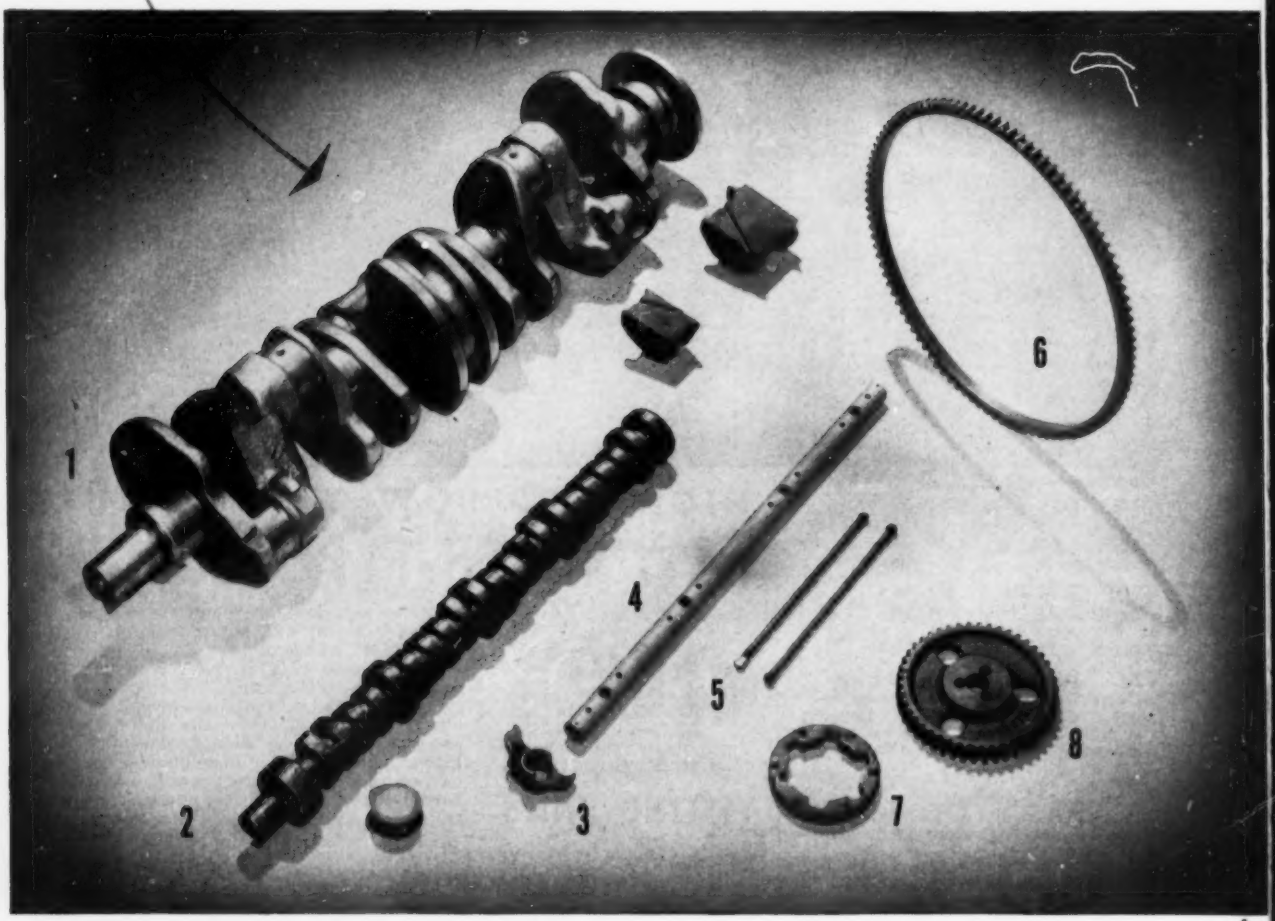

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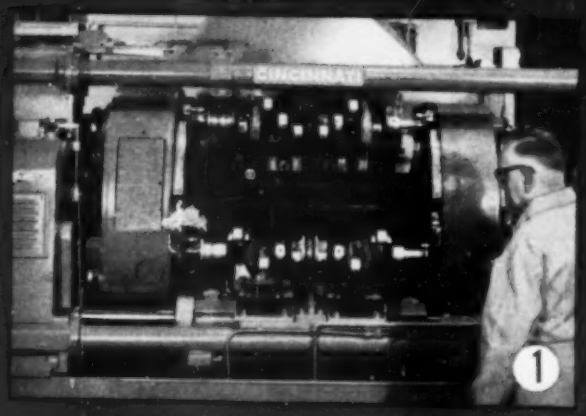
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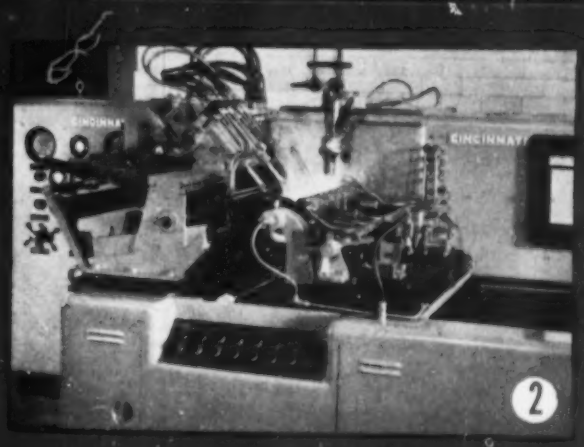
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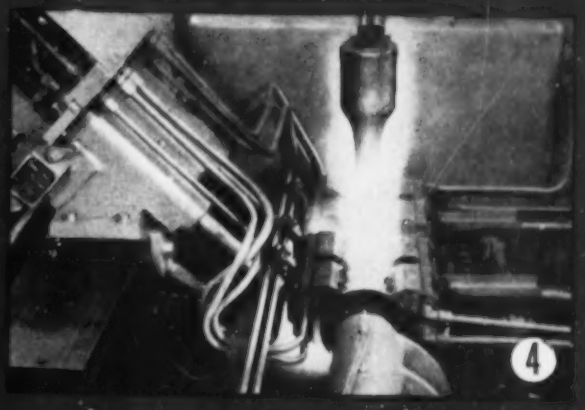
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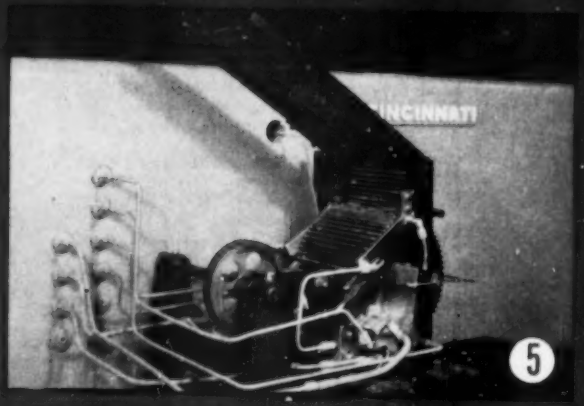
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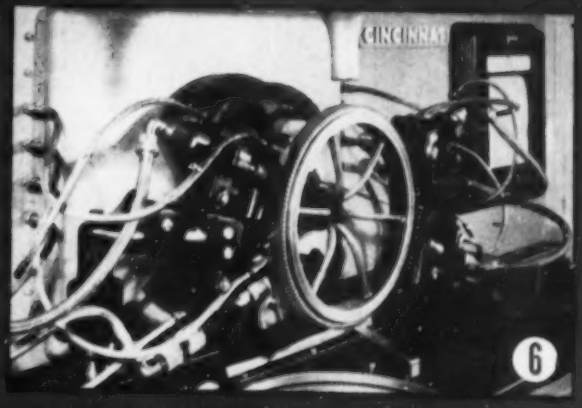
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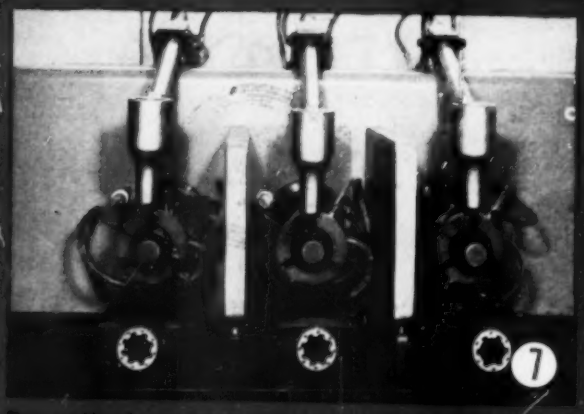
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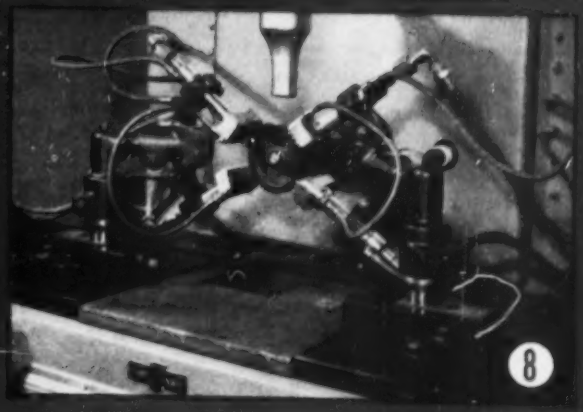
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753. Furnaces
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754. Furnaces
Bulletin 435 describes new furnaces for tool room, experimental or small batch production. Gas, oil, electric. Muffle or direct heated. *W. S. Rockwell*

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12-page Catalog I-2 on method of atmospheric control for hardening high speed steel. *The Sentry Co.*

756. Furnaces, Heat Treating
Bulletin on fuel and electric furnaces for heat treating. *Dempsey*

757. Furnaces, Heat Treating
12-page bulletin on conveyor furnace, radiant tube gas heated, oil or electrically heated. *Electric Furnace Co.*

758. Furnaces, Laboratory
26-page "Construction of Laboratory Furnaces" contains many diagrams, charts, tables, and information on how to construct furnaces. *Norton Co.*

759. Furnaces, Rotary Hearth
Folder giving drawings, dimensions, capacity, Btu required for drawing, annealing, forging. *Gas Machinery*

760. Gas Analysis
Data on positive, nondispersion-type infrared analyzers for laboratory and industry. *Minneapolis Honeywell*

761. Gas Analysis
48-page catalog 81 on equipment and accessories for gas analysis. *Burrell*

762. Gear Hardening
Folder on application of induction heating to high-production hardening of gears. *Westinghouse*

763. Globar Furnaces
Bulletin 153 describes nine types of furnace using silicon carbide heating elements for temperatures to 2600° F. *Hevi Duty*

764. Gold Plating
Article on analysis of gold and gold alloy plating solutions gives all currently available procedures. *Technic*

765. Graphite Electrodes
Vest-pocket notebook containing 90 pages of information on electric furnace electrodes and other carbon products. *Great Lakes Carbon Corp.*

766. Grinding Magnesium
Data on how to grind and polish magnesium alloys includes grinding wheel recommendations, procedures, dust collection and safety precautions. *Norton*

767. Handling Devices
Pamphlets on clamps for lifting and handling. Their application to various industries. *Merrill Bros.*

768. Hardening Stainless
24-page "Story of Malcomizing" describes surface hardening of stainless steels. *Lindberg Steel Treating Co.*

769. Hardness Conversion
Wallet-size celluloid card gives hardness and tensile conversions. *International Nickel*

770. Hardness Tester
Booklet describes two models of Penetrascope hardness testers. *C. Tennant*

771. Hardness Tester
Data on micro-hardness tester with optional Vickers or Knoop diamond. *Geo. Scherr*

772. Hardness Tester
Circular on portable hardness tester in sizes for work 1 to 6 inches round and flat. *Ames Precision*

773. Hardness Tester
20-page book on hardness testing by Rockwell method. *Clark Instrument*

774. Hardness Tester
4-page bulletin on Brinell hardness tester weighing 26 lb. for portable and stationary use. *Andrew King*

775. Hardness Tester
Bulletin on Impressor portable hardness tester. *Barber-Colman*

776. Heat Resistant Alloy
Pyrasteel bulletin describes chromium-nickel-silicon alloy for service economy in resisting oxidation and corrosion to 2000° F. *Chicago Steel Foundry*

777. Heat Resistant Alloy
Bulletin No. 1 on HR-3 (37% Ni, 17% Cr) cast alloy for parts subject to corrosion and high temperatures. *Standard Alloy*

778. Heat Resistant Finish
Bulletin 531 on silicone-base heat-resistant finish. *Midland Ind. Finishes*

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Bulletin 850 on shaker-hearth furnace for bright carburizing, carbonitriding, hardening. *Hevi Duty Electric*

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24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. *Nitrogen Div.*

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Property data for 21% Cr, 9% Ni heat-resistant alloy. *Electro-Alloys Div.*

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24-page bulletin on metal conveyor belts. *Wickwire Spencer*

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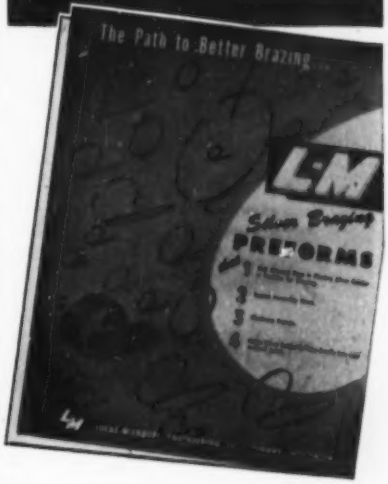

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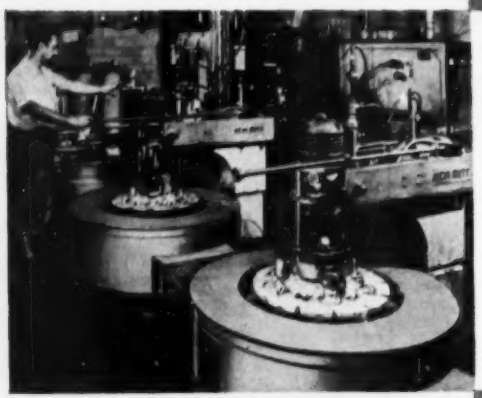

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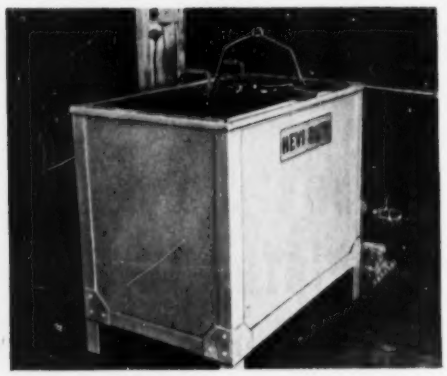
This versatile furnace may be used for all major heat treating operations. Multiple zone temperature regulation and the positive pressure atmosphere control assure uniform results from heat to heat. Bulletin HD-646.



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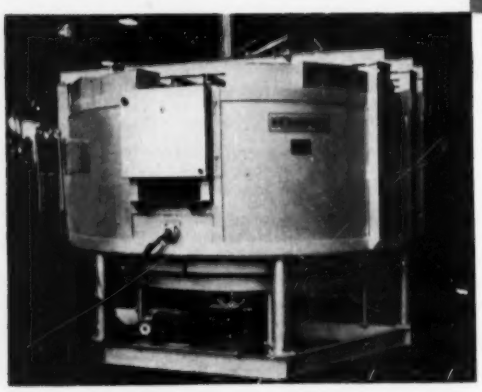

HEVI DUTY ROTARY HEARTH FURNACE

Designed to operate at temperatures up to 2500° F. Many of these furnaces are heating jet engine parts prior to forging. A protective atmosphere prevents scale and the decarburization of high temperature alloys. Maximum capacity is 1500 pounds per hour. Bulletin 153.

At your service are experienced Hevi Duty Engineers able to recommend that exact furnace for your production system.

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Data on magnetism in stainless steel castings, its importance in chromium and chromium nickel castings and wrought alloys. *Empire Steel Castings*

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Booklet on how brushes are used for cleaning welds, stainless sheets, hot cast iron, automotive parts, brass fixtures. *Pittsburgh Plate Glass, Brush Div.*

807. Melting Aluminum
Bulletin 310 on furnaces for melting aluminum. *Lindberg Eng'g.*

808. Melting Furnace
Bulletin gives specifications, diagrams, performance and other technical data on Simplex melting furnaces. *Lindberg Engineering*

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810. Metal Cutting
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Data on industrial instrumentation applications of the Ohmart cell, the radio-

(Continued on page 32A.)

HEAT TREATING FURNACES for INDUSTRY

HEVI DUTY

HEVI DUTY BOX TYPE FURNACE

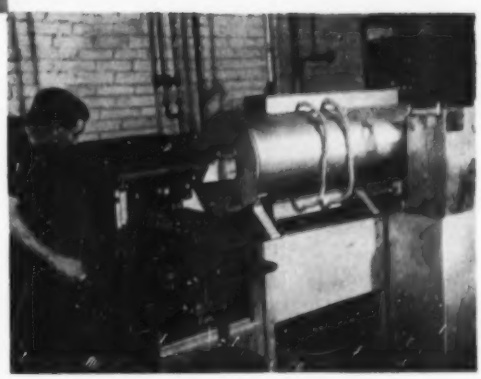
Hardening piston rings at 1850° F. is one exacting use of this furnace. Hevi Duty design and construction assures uniform and fast heating with low maintenance costs in electric furnaces for many applications.

HEVI DUTY SALT OR LEAD BATH POT FURNACE

Salt bath hardening, tempering, and cyaniding without scale are major applications of the Hevi Duty Electric Pot Furnace. A case of .004 to .005 is obtained in 15 to 20 minutes on parts immersed in cyanide salt at 1550° F.

HEVI DUTY SHAKER HEARTH FURNACE

This modern production tool will either carburize, nitride, dry cyanide, or bright harden up to 150 pounds of work per hour. The work passes through the furnace and drops directly into the oil quench. Results are clean, uniformly treated parts with minimum distortion. Bulletin HD-850.



Hevi Duty Electric Company designs, and builds many types of electric heat treating furnaces and gas generators. Call on us to help solve your heat treating problems.

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Heat Treating Furnaces... Electric Exclusively

Dry Type Transformers *Constant Current Regulators*

(Continued from page 31.)
active sensitive element which converts nuclear radiation into electrical energy. *Minneapolis-Honeywell*

823. Oil Quenching
Catalog V-1146 on self-contained oil cooling equipment. Selection tables for volume of oil required and oil recirculation rates. *Bell & Gossett*

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Latest periodic chart of the elements. Green and black, 11 by 14 in., official 1952 data. *General Electric*

825. Phosphate Coating
12-page "Phosphate Coating Chemicals and Processes" gives data on paint bonding, rust proofing, protecting friction surfaces, improving drawing and extrusion. *American Chemical Paint*

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80-page book "Efficient Pickling" covers all variables of process. Many charts and tables. *American Chemical Paint*

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Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

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836. Recirculating Furnaces
16-page Bulletin 81 describes heat treating furnaces for ferrous and nonferrous parts and other heat treat equipment. *Despatch Oven*

837. Recorder
Bulletin C2-2 on electronic strip chart recorder for temperature, speed, static strain, voltage, amperage. *Wheelco*

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4-page bulletin on multi-point circular chart recorders. *Fielden Instrument Div.*

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Bulletin discusses refractories and heat-resistant concrete. *Lumnite Div.*

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844. Salt Bath Control
Data sheet 5.2-5 describes instrumentation for temperature control of salt baths in heat treatment of high speed steel. *Minneapolis-Honeywell*

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12-page bulletin B-40 describes continuous and batch descaling lines for removing oxide from steel, bronze, copper, stainless and titanium. *Drever*

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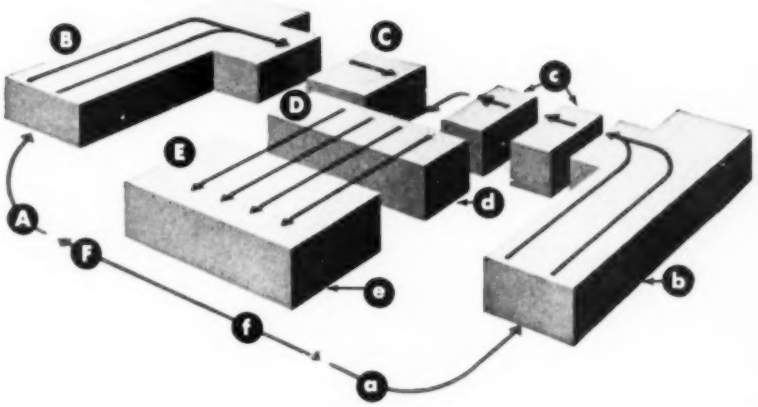
Heat Treat Furnace Layout

by *Holcroft* ...6th of a Series



A. Load
B. 2-row continuous atmosphere carburizing furnace
C. Oil quench
D. 4-row washing machine
E. 4-row draw furnace
F. Unload

a. Load
b. 2-row continuous atmosphere carburizing furnace
c. Salt bath quench and air blast cooling station
d. 4-row washing machine
e. 4-row draw furnace
f. Unload

How to Beat Heat Treat Costs!

Here's a furnace layout which is tricky—yet functional; one which steps up production—yet is flexible enough for different cycles!

Holcroft designed it to handle a variety of transmission parts requiring different processing cycles. In one case, parts are carburized, oil quenched, washed, and drawn. In the other, the stock is carburized, quenched in a salt bath, cooled with an air blast, washed, and drawn. The wash machine and draw furnace, though common to both cycles, are electrically independent.

While production flows at a rapid pace, the battery is so automatic that only a two-man crew is required for loading and unloading—one man on each side!

This is the type of furnace engineering that pays off in lower heat treat costs *to you!* And it's available on simple single-furnace jobs, or complex multi-furnace installations. It will pay you to write for more information—today! Holcroft & Company, 6545 Epworth, Detroit 10, Michigan.

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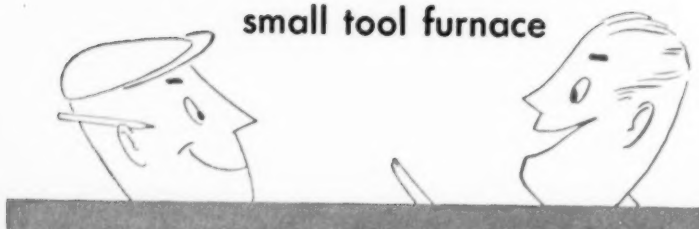
with a Waltz

small tool furnace



This WALTZ HEAT TREATING PLANT includes a pre-heat furnace, high heat furnace and quench tanks, in a unit designed for convenient positioning in your shop. Furnace sections, equipped with casters, have temperature range permitting treatment of all high speed steels including cobalt.

Owning a Waltz Furnace eliminates (1) cost of sending out small parts, (2) materials-handling expenses, and (3) production delays caused by waiting for outside service.

A complete line of Waltz standard or special heat-treating furnaces, using all types of fuels, are built to suit your requirements.

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bars to 1800° F; des
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ring forgings. *Pete*

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cations of nine different Govern-agencies. *American Brass*

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Spot Welding

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Stainless Steel

sheet on wrought alloy type 330, i—15% Cr. Mechanical properties of 1800° F; design stresses to 2100° F. *Alloys*

Stainless Steels

ge book on uses of stainless steels. *Metallurgical*

Stainless Tubing

etin No. S-222 gives property, appli-and chemical data of seamless and stainless steel tubing. *Globe Tubes*

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ge book on corrosion, uses and tion of stainless steel tubing. *Steel ubes Div., Republic*

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stock list on 52100 tubing, bars, and rgings. *Peterson Steels*

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ge folder on portable freezer, 110-.c., operating to -180° F., for fitting, hardening, stabilizing and . *Webber Appliance*

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on chest for use down to -95° F. duction use and testing. *Revco*

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877. Tempilstiks

"Basic Guide to Ferrous Metallurgy", a plastic laminated wall chart in color. *Claud S. Gordon*

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639. Hardness Tests

New pocket-size celluloid chart gives corrections to be added to hardness values obtained on cylindrical surfaces

of various diameters, when a comparison is needed between cylinder hardness and hardness of the same material tested flat. *Wilson Mechanical Instrument Div.*

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878. Testing Controllers

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28-page catalog on screw power universal testing machines and accessories. Construction specifications. *Riehle*

880. Thermocouple Protection

4-page Bulletin No. P1261 on metal-ceramic thermocouple wells. *Bristol Co.*

881. Thermocouples

20-page Bulletin 714 on thermocouples, protecting tubes and wells, insulators, leads, connectors, heads. *Gen. Electric*

882. Tool Steel

20-page booklet on selection of proper tool steel support material for use with carbide tools. *Allegheny Ludlum*

883. Tool Steel

Folder on high carbon, high vanadium tungsten base high speed steel. *Latrobe*

884. Tool Steel Color Guide

Color guide to estimate temperatures has heat colors on one side and temper colors on the other. *Bethlehem Steel*

885. Tool Steel Selector

Selector is handy chart featuring general and heat treating data on non-deforming, water hardening, high speed tool and hollow die steels. *A. Milne*

886. Tool Steel Selector

Twist the dial of the 9-in. circular selector and read off the tool steel for your application. *Crucible Steel*

887. Tong Ammeters

Bulletin on tong test ammeters, a.c. or d.c., for instant current measurements without breaking circuit or touching conductor. *Columbia Electric*

888. Tungsten Carbide

72-page catalog on tungsten carbide products, including tools, dies, gages, rolls. *Metal Carbides Corp.*

889. Vacuum Gage

Folder GEC 986 on molecular vacuum gage for measuring pressures without external detectors. *General Electric*

890. Vacuum Metallizing

Brochure on "Vacuum Metallizing Today" gives applications and techniques. *Stokes Machine*

891. Vacuum Pumps

Bulletin V51B describes line of vacuum pumps. *Kinney Mfg.*

892. Welding Equipment

Catalog on Cadwell process and arc-welding accessories. *Erico Products*

893. Wire Baskets

84-page book on fabricated baskets for dipping and heat treating. *Cambridge Wire Cloth*

894. Zirconia

Folder on new, patented process in which each zirconia crystal is stabilized. Characteristics of stabilized zirconia. *Zirconia Corp. of America*

March, 1954

650	675	700	725	750	775	800	825	850	875
651	676	701	726	751	776	801	826	851	876
652	677	702	727	752	777	802	827	852	877
653	678	703	728	753	778	803	828	853	878
654	679	704	729	754	779	804	829	854	879
655	680	705	730	755	780	805	830	855	880
656	681	706	731	756	781	806	831	856	881
657	682	707	732	757	782	807	832	857	882
658	683	708	733	758	783	808	833	858	883
659	684	709	734	759	784	809	834	859	884
660	685	710	735	760	785	810	835	860	885
661	686	711	736	761	786	811	836	861	886
662	687	712	737	762	787	812	837	862	887
663	688	713	738	763	788	813	838	863	888
664	689	714	739	764	789	814	839	864	889
665	690	715	740	765	790	815	840	865	890
666	691	716	741	766	791	816	841	866	891
667	692	717	742	767	792	817	842	867	892
668	693	718	743	768	793	818	843	868	893
669	694	719	744	769	794	819	844	869	894
670	695	720	745	770	795	820	845	870	
671	696	721	746	771	796	821	846	871	
672	697	722	747	772	797	822	847	872	
673	698	723	748	773	798	823	848	873	
674	699	724	749	774	799	824	849	874	

METAL PROGRESS,

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Title

Company

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City and State

Postcard must be mailed prior to June 1, 1954
Students should write direct to manufacturers.

with LINDE Oxygen you get the BIG PLUS

. . . that's LINDE SERVICE

In every metalworking operation, new materials, changing requirements, and unexpected emergencies create special situations that demand skill and experience.

That's where LINDE SERVICE comes in. LINDE's field engineers stand ready to help you meet such conditions. They're backed by LINDE laboratories, where research in oxygen manufacture, distribution systems, and application methods has been carried on for more than 40 years.

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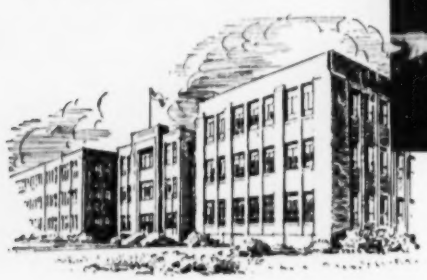
LINDE SERVICE

is the unique combination of research, engineering, and more than 40 years of accumulated know-how that is helping LINDE customers save money and improve production in their uses of oxygen and oxy-acetylene processes.



If your company uses oxygen, LINDE SERVICE can mean dollar savings to you. Let us tell you how.

LINDE AIR PRODUCTS COMPANY

Division of UNION CARBIDE AND CARBON CORPORATION

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Offices in Principal Cities

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Linde Trade-Mark

"Desegatized"
high production
AIR-HARDENING
Die Steel*
Manufactured under
Patent No. 2204283

Tests show as much as
50% reduction in
machining time

No change in physical properties or in the heat treatment normally associated with D-2 type die steel.

Contact your Latrobe representative or write direct to Latrobe, Pa. for complete information.

*D-2 Type

Latrobe
STEEL COMPANY
LATROBE, PA.

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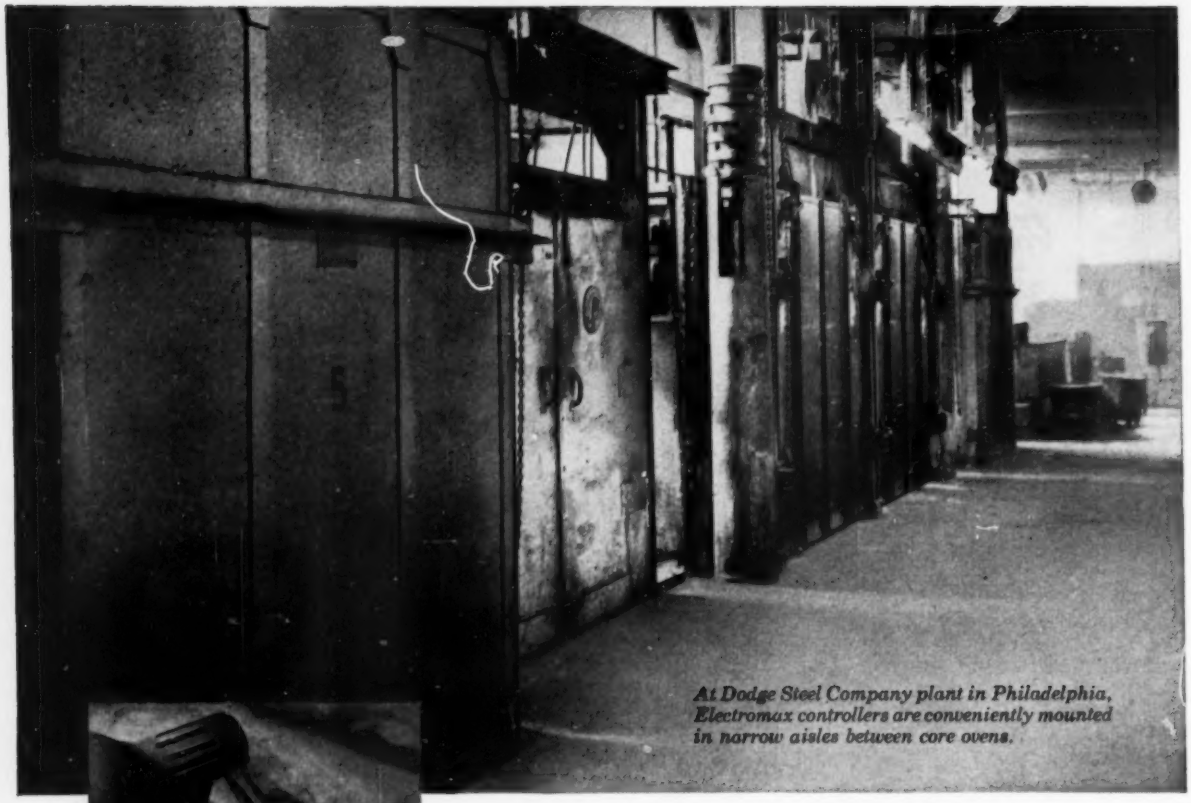
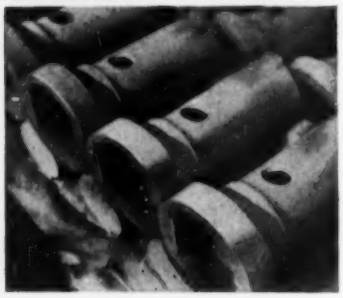


At Dodge Steel Company plant in Philadelphia, Electromax controllers are conveniently mounted in narrow aisles between core ovens.



With drying ovens under Electromax control, danger of either wet or burnt cores is practically eliminated. Cores, above, come out of the oven clean and thoroughly dry.

No repairs in 5 years

FOR DODGE STEEL CO'S ELECTROMAX® CONTROLLERS

Over 5 years ago, Dodge Steel Co. put Electromax controllers on their core ovens. Since then . . . thanks to the dependable, maintenance-free operation of these controllers . . . not a core has been rejected because of off-temperature baking. The result . . . reduced operating costs and increased production.

Even under 24 hour operation and daily exposure to high ambient temperatures, dust, dirt and vibration, oven temperatures are always within ±5 F.

During the entire period, Electromax has required *no maintenance* . . . is *still* assuring the right temperature for each bake.

Electromax may be the inexpensive, electronic controller you've been looking for. Applied to either fuel-fired or electric furnaces, it controls temperatures up to 1000 F.

For full details, contact any of our branch offices or write directly to 4927 Stenton Ave., Philadelphia 44, Pa.

LEEDS LN **NORTHRUP**
instruments *automatic controls • furnaces*

Jrl. Ad ND47(5)

Mr. Design Engineer...

do a little exploring

Highly stressed structural bracket, impact forged in one operation to produce precise bore perpendicular to base.
2½"
5/32"
3¼"

You can make this highly stressed structural bracket by:

1 Machining from a typical forging

Metal waste	—High
Machining cost	—High
Physical properties	—High
Material cost	—High

2 Machining from a casting

Metal waste	—High
Machining cost	—High
Physical Properties	—Low
Material cost	—Low

3 Hogging from bar stock

Metal waste	—High
Machining cost	—High
Physical properties	—Fair
Material cost	—High

4 Hunter Douglas Impact Forging

Metal waste	—Low
Machining cost	—Low
Physical properties	—High
Material cost	—Low

Every method offers an advantage, but Impact Forging offers every advantage.

Discover the advantages of

IMPACT FORGING

FROM

HIGH STRENGTH ALUMINUM ALLOYS

IMPACT FORGING is a new technique perfected by Hunter Douglas to mass produce heat-treatable aluminum alloy parts with close dimensional tolerances and forged grain flow. Impact Forging forces the material to the desired shape by direct compression with little metal waste. Many times the part is impact forged to final print in one operation, eliminating any secondary machining operations.

Impact Forging offers you variable side walls, zero draft, and close dimensional tolerances in a variety of tubular, rectangular, and symmetrical shapes. The economic advantages of Hunter Douglas Impact Forging can be best realized if you are designing a part for production in quantities of 1 thousand to 1 million a month. Impact Forging gives close dimensional tolerances, micro-precise surface finish, and the high physical properties of a forging. Spark your imagination and improve your position in the competitive field by investigating the advantages of Hunter Douglas Impact Forging.

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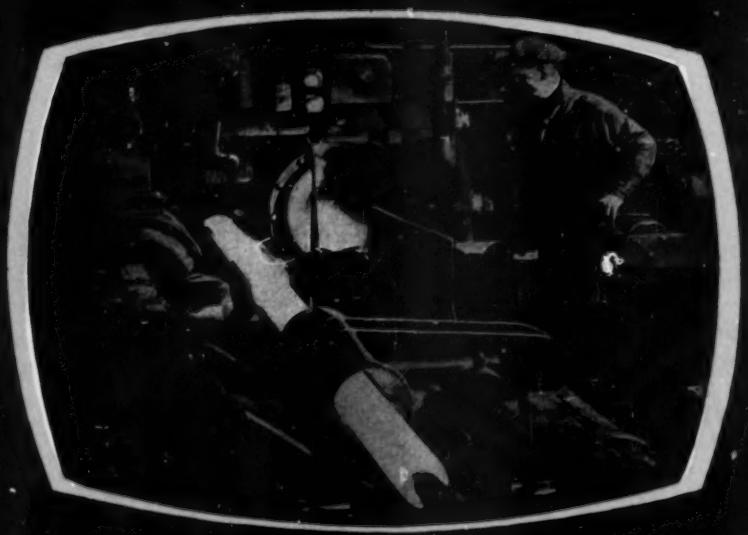
telling the story of 'dag' dispersions



Here is a Lubricant that Can't Burn Off, Flake, or Gum Up

'dag' dispersions of colloidal graphite form microscopically thin *dry lubricating* films which fight friction beyond the burning-points of most oils. They cannot burn off, flake, or gum up at ordinary metalworking temperatures. These dry films are unaffected by heat up to 750°F. . . . under some conditions up to 3,000°F.

'dag' dispersions can profitably be used in stamping, deep drawing, piercing, casting, forging, stretch-forming, and wire drawing operations. They lessen die wear, produce smooth parting and clean surfaces, minimize scaling and sticking, reduce tearing and rippling, and assure uniform dimensions.

For more details on metalworking applications, write for Bulletin No. 426-C7.

Dispersions of molybdenum disulfide are available in various carriers.

We are also equipped to do custom dispersing of solids in a wide variety of vehicles.

dag DISPERSIONS

Acheson Colloids Company, Port Huron, Mich.
...also ACHESON COLLOIDS LIMITED, LONDON, ENGLAND

try 'dag' resin bonded dry films for permanent lubrication

The answer to most of your questions about stainless steels are right at your finger tips, when you use Crucible's unique new Stainless Steel Selector.

Want to know the machinability characteristics of a stainless grade? Resistance to corrosion or scaling? Physical or mechanical properties? You can get the answers to these and other questions simply by setting the arrow on the Selector slide at the proper window. It's just as quick and easy as that.

And almost as fast as you get the answer, you can get the steel you need. For many of the REZISTAL stainless steels shown on the Selector are carried in stock in Crucible warehouses conveniently located throughout the country.

To get your free copy just fill in and mail the coupon. Better do it now.

HOW THE SELECTOR WORKS:

Start with the problem. For example, resistance to corrosion in contact with copper sulfate. Just set the slide at the proper index number shown on the Selector (in this case on the back), and you have the answer in a second – grades 302 and 316 are fully resistant to this form of attack.

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CRUCIBLE first name in special purpose steels

54 years of Fine steelmaking

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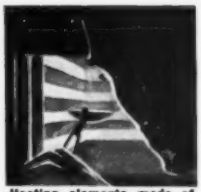
How Hot can a Jet Get?

Whoooosshh! Jet engines generate a powerful amount of heat . . . heat which, uncontrolled in flight, would cause disastrous metallurgical distortions within the delicately balanced engine. So the problem is . . . or rather *was* . . . how to provide a dependably accurate means of measuring exhaust temperatures so that the pilot might have control over how hot his jets get.

And the answer? Special wiring harnesses running from engine to instrument panel . . . harnesses now made exclusively with Hoskins Chromel-Alumel thermocouple alloys.

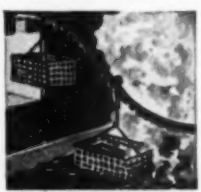
Yes, wherever durability and accuracy are required in a thermocouple . . . whether for jet engines or industrial furnaces . . . you'll find Chromel-Alumel *right* for the job. Extremely durable . . . highly resistant to heat, corrosion, oxidation . . . guaranteed to register true temperature-E.M.F. values within specified close limits.

That's only part of Hoskins' product picture, though. Other specialized quality-controlled alloys developed and produced by Hoskins include: Alloy 785 for brazing belts; Alloy 717 for facing engine valves; special alloys for spark plug electrodes; Alloy 502 for heat resistant mechanical applications. And, of course, there's Hoskins CHROMEL . . . the *original* nickel-chromium resistance alloy used as heating elements and cold resistors in countless different products.



Heating elements made of Hoskins Chromel deliver full-rated power throughout their long and useful life.

Sparks fly better, last longer in today's spark plugs . . . thanks to Hoskins' spark plug electrode alloys.



Hot stuff for hot jobs! Hoskins Alloy 502 is ideally suited to many mechanical-structural applications.

Chromel NICKEL CHROMIUM WIRE

HOSKINS

MANUFACTURING COMPANY

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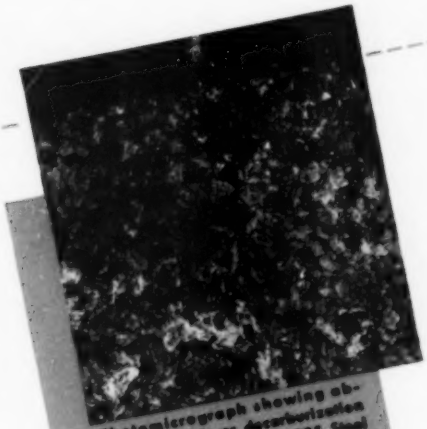
NEUTRAL HARDENING

means just what it says . . .

No Scale
No Decarb



Photomicrograph showing absence of scale or decarburization in a section of S.A.E. 1085 Steel (X100) hardened at 1500° F. in a neutral salt bath and quenched in oil. (Etched in 2% Nital.)

Automotive spline shafts being heated in a neutral salt bath equipped with a screw-conveyor mechanism. Temperature of the work is held within 5°F., even in this relatively large bath — 6 ft. long, 2 ft. wide and 2 ft. deep.

For more information on AJAX Electric Salt Bath Furnaces and their many uses — hardening, annealing, brazing, tempering, cleaning, quenching, etc. — metallurgists and metalworking executives are invited to write on their firm's letterhead for the new 72-page Booklet No. 116B.

AJAX ELECTRIC COMPANY

910 Frankford Ave., Philadelphia 23, Pa.

The World's Largest Manufacturer of Electric Heat Treating Furnaces Exclusively!

Associate Companies: **Ajax Engineering Corp.**
Ajax Electric Furnace Corp. **Ajax Electrothermic Corp.**
***In Canada:* Canadian General Electric Co., Ltd., Toronto, Ont.**

. . . and an amazing volume of work can be treated in small, relatively inexpensive salt bath equipment.

A neutral salt bath provides an ideal means of heating carbon or alloy steel parts without any deleterious effect on the surface, such as scaling, pitting, carburizing or decarburizing. The bath completely seals out all air while work is heating . . . and a thin film of salt remains when work is removed, protecting it right up to the instant of quenching.

All "protective atmospheres," gas generating equipment and specially trained operators required for their use are eliminated . . . with corresponding savings in initial expense, operating costs and floor space requirements.

Heating cycles are 4 to 6 times faster than in atmosphere or radiant type furnaces — enabling small furnaces to handle a large volume of work — because heat is transferred by conduction rather than by convection or radiation, all surfaces of the work being in direct physical contact with the molten salt. Heating, therefore, is both rapid and uniform . . . eliminating the cause of most distortion.

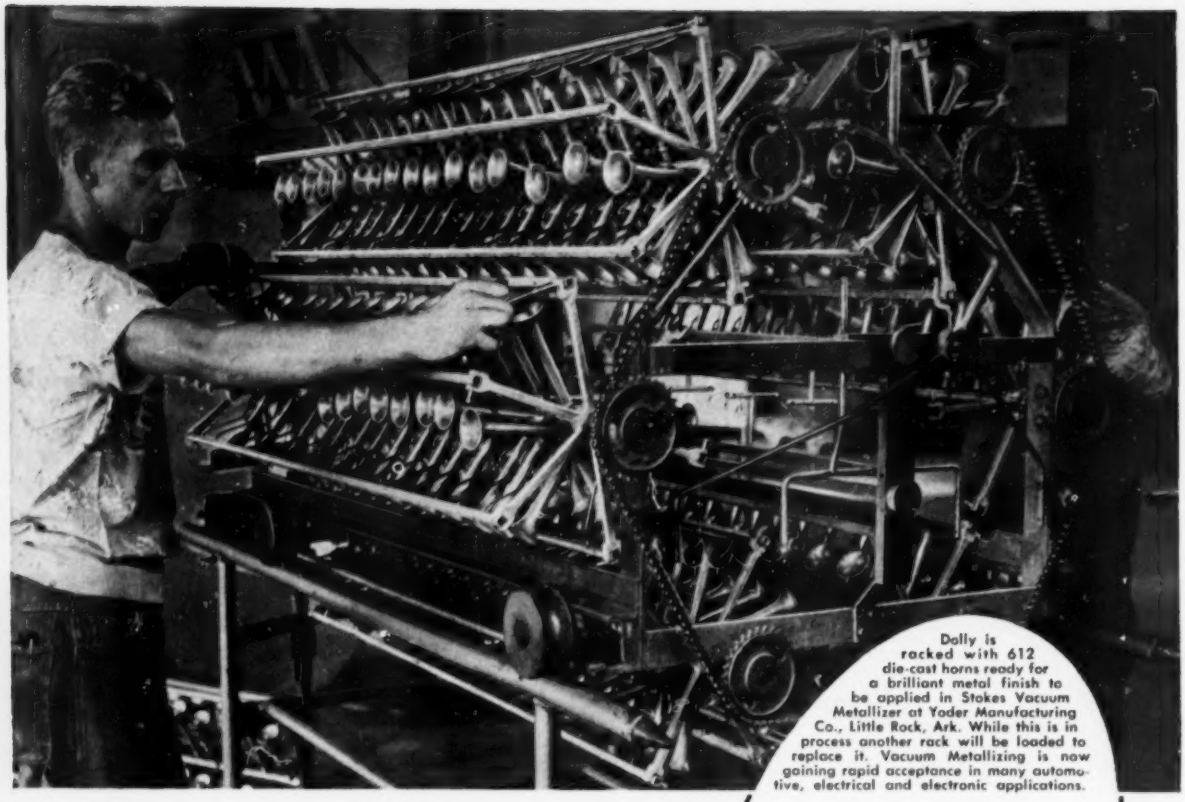
Unique internal heating principle of the AJAX furnace — utilizing patented, closely-spaced, immersed electrodes — produces an automatic electrodynamic stirring action within the bath which contributes to faster heating of the work and assures a temperature variation of less than 5° F. throughout the bath.

This internal heating feature also permits use of long-lived ceramic pots, avoiding contamination of neutral baths by metallic oxides produced by metal pots.

The advantages of hardening in a neutral salt bath can be further enhanced by use of an isothermal salt bath quench (martempering or austempering) to hold distortion to a minimum and eliminate quench cracking.

TRADEMARK

AJAX HULTGREN **ELECTRIC SALT BATH FURNACES**



Dolly is racked with 612 die-cast horns ready for a brilliant metal finish to be applied in Stokes Vacuum Metallizer at Yoder Manufacturing Co., Little Rock, Ark. While this is in process another rack will be loaded to replace it. Vacuum Metallizing is now gaining rapid acceptance in many automotive, electrical and electronic applications.

In Minutes These 612 Die-cast Horns will be Brilliantly Metal-coated!

Metallic finishes in many metals and many colors are now applied by Vacuum Metallizing and the product is ready for lacquering and packaging without hand work. No plating or finishing plant can afford to ignore the tremendous opportunities which Vacuum Metallizing creates.

Ornaments and display materials, toys, trophies, furniture handles, emblems, jewelry, nameplates, reflectors and many other metal parts are now largely vacuum metallized. Automobile parts are a new and fast-growing market. Electrical and electronic parts offer unlimited possibilities. Some installations deliver as high as 100 loads of finished parts per 24-hour day from a single Stokes Vacuum Metallizing unit without use of specially skilled labor. Stokes trains your workmen and you start into production.

Units of 24, 36, 48 and 72-inch diameter are available, some fully automatic in operation. Floor space requirements are low, as these are integrated "package" units of the fastest and most efficient type.

Stokes Laboratory will metallize your samples, evaluate your application, recommend techniques to be employed, plan cycles, report on costs . . . and share with you the benefits of Stokes' 40 years of leadership in high-vacuum technology.

Write today for a comprehensive brochure, "Vacuum Metallizing Today," which describes the applications and techniques of Vacuum Metallizing.

F. J. Stokes Machine Company
Philadelphia 20, Pa.

STOKES

STOKES MAKES: High Vacuum Equipment, Vacuum Pumps and Gages / Industrial Tabletting, Powder Metal and Plastics Molding Presses / Pharmaceutical Equipment

For Removing RUST and SCALE

"ALKA-DEOX" DERUSTING PROCESS — An alkaline electrolytic process for rapid, removal of rust and scale from steel, cast iron and malleable iron. Operates at room temperature. No attack on basis metal. Uses Enthone Compound 134.

"COMPOUND 42" — CLEANER AND RUST REMOVER FOR STEEL. A solvent acid cleaner for rapid removal of oil, rust and oxide from steel, zinc, aluminum and other metals to prepare them for painting or organic finishing.

"DESCALER 2A" — POWDERED ACID PICKLING COMPOUND. A powdered acidic compound added to water to make pickling solutions for iron and steel. Safer to handle than sulphuric acid. Gives controlled acidity to prevent overpickling.

"ACTANE 33" — POWDERED COMPOUND REPLACES HYDROFLUORIC ACID. A dispersing agent added to acid pickles to remove colloidal and siliceous films from metals. Also an additive for sulphuric and nitric acid pickles to promote faster pickling of stainless steel, aluminum and titanium.

"ACID ADDITION AGENT"—STOPS ACID FUMES. A surface active material extensively used in acid pickles to reduce fuming, to give better wetting and to promote better pickling.

"INHIBITOR 8" — STOPS ACID ATTACK ON STEEL. An all-purpose inhibitor for acids including sulphuric and hydrochloric acids to stop attack on steel during pickling.

Write for fully descriptive literature.

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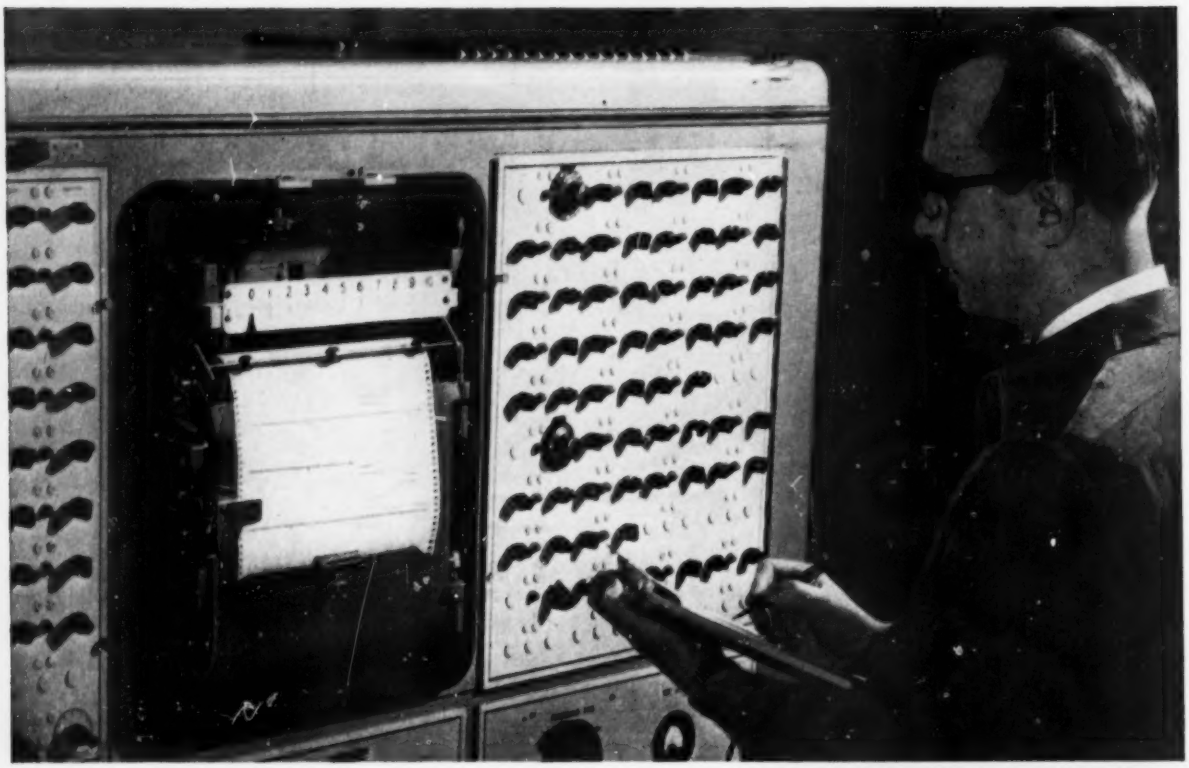
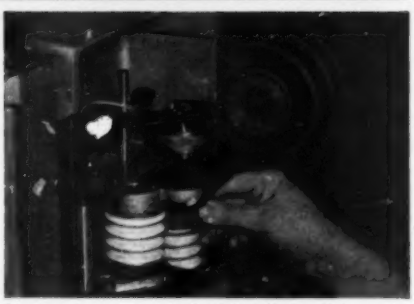
SURE, we're sure you're getting the right copper alloy!



CHASE metallurgists use fantastically accurate instruments to check the brass shipped to you in wire, rod, sheet or tube.

The Quantometer, for instance, tests a brass sample for 18 elements in 1½ minutes.

An Electron Microscope, Spectroscope, and an X-ray Diffraction Unit are also part of Chase laboratory equipment so that we can be absolutely certain that the Chase brass you buy has exactly the right composition, grain structure, temper, dimensions and other physical characteristics your product requires.



Here a brass sample is being inserted into the arc-spark stand of the Quantometer for analysis. In a matter of only 1½ minutes, sample will be completely analyzed.

Chase® BRASS & COPPER

WATERBURY 20, CONNECTICUT • SUBSIDIARY OF KENNECOTT COPPER CORPORATION

The Nation's Headquarters for Brass & Copper

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A HUGE SAVING ON A HUGE JOB WITH dy-chek

5 MILES OF FLAW DETECTION

"The others wanted weeks... but dy-chek did it in days..."

JAMES A. MITCHELL, *Plant Supt.*
Standard Steel Corporation, Los Angeles, Calif.

Five miles of welding that must be checked for flaws carefully and accurately. This was the problem faced by Standard Steel while constructing a gigantic vacuum tower for one of America's leading petroleum refiners. Here was a job where accuracy was vital and where time and cost factors were of major importance. After checking other processes calling for importation of outside specialists and with *completion time measured in weeks*, Standard Steel turned to Turco and the dye-penetrant method.

With Turco Dy-Chek *the huge job was accomplished in days rather than weeks...was done with Standard Steel personnel*...and at a saving in cost that amounted to *hundreds upon hundreds of dollars.*

You may not be building vacuum towers over 50 feet high or dealing with welds 5 miles in length... but if you are fabricating metal in *any size or shape* you'll find those hidden flaws with greater certainty... you'll find them faster and at lower cost if you'll turn to Turco... Turco Dy-Chek... *first!*

FOUR SIMPLE STEPS...

1. Clean Surface
2. Apply Dy-Chek Dye Penetrant
3. Remove excess Dye Penetrant with Dy-Chek Dye Remover
4. Apply Dy-Chek Developer. Flaws are revealed.

Regardless of *size*...regardless of *shape*...the Turco Dy-Chek dye-penetrant process will locate existing flaws *in any metal.* No expensive equipment is needed...no trained personnel is required. Flaw detection the Dy-Chek way is simple, certain and fast. *Initial costs are low... operating costs are low.* Why not investigate today?

For Cleaning or Metal Conditioning Problems... Turn to Turco First!

Hot or Cold Immersion

Spray Washing

Steam Cleaning

Solvent Spray

Phosphate Coating

Paint Removing

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From coast-to-coast and border-to-border Turco specialists and Turco warehouses are in most principal cities. Consult your local classified phone book for the one nearest you.

Write for FREE Descriptive Booklet.
Don't be without this completely informative, profusely illustrated booklet on flaw detection. It's free and yours for the asking!

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The most widely used high temperature block insulation for over a quarter century...

SUPEREX® high temperature block insulation has long been industry's No. 1 choice for service temperatures up to 1900F. It provides *major* economies . . . reduces fuel costs, cuts heat losses, keeps maintenance expense down, costs less to install and has long service life.

These are the reasons why 90% of the nation's hot blast stoves are Superex insulated . . . and why the low cost open hearth steel producers use Superex in their regenerators.

Made of specially selected and calcined diatomaceous silica blended with other insulating materials and bonded with asbestos fiber, Superex will safely withstand temperatures up to 1900F with negligible shrinkage.

Superex has been used with outstanding success in all types of industrial and metallurgical furnaces and ovens, stationary and marine boilers, auxiliary power plant equipment, regenerators, kilns, roasters, high temperature mains, flues and stacks.

Superex has all these important advantages...

Low thermal conductivity—Exceptionally high heat resistance (1900F) combined with excellent insulating value.

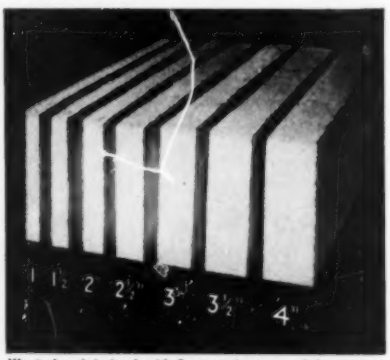
Light weight—Approximately 2 lb per sq ft per in thickness.

Great physical strength—Approximately 6 tons pressure per sq ft are required to compress Superex ½ in.

Long, efficient service life—Superex maintains high insulating value indefinitely—will not disintegrate in the service for which it is recommended.

Fast, easy application—Superex may be cut with an ordinary knife or saw for fitting around openings or to irregular surfaces. Because of its light weight and convenient sizes, Superex assures fast and economical installations.

For complete information about Superex block insulation, write for Brochure IN-134A. Address Johns-Manville, Box 60, New York 16, N. Y. In Canada, write 199 Bay Street, Toronto 1, Ontario.



Waste is minimized with Superex because of the variety of thicknesses available. Special shapes and intermediate thicknesses between those shown are also available.

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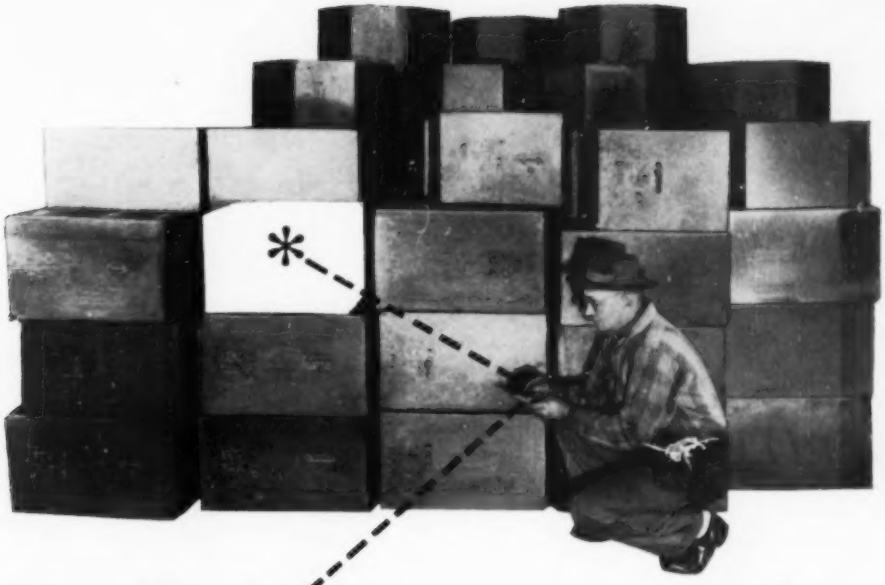
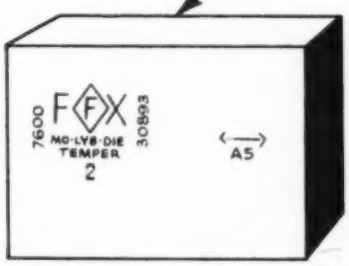


Finkl Die Blocks have your number



The entire history of a Finkl die block is hot stamped on its side. For instance, #7600 is the heat or melt number used to fill the order. #30893 is the production number. The FX and Diamond F is the trademark of the special steel used. Temper 2 signifies the hardness to which the block is heat treated. The arrow shows the direction flow of the metal as a guide for die sinking. The A5 under the arrow indicates the block location in the ingot runout.

All of this means that we process our forgings and die blocks according to the requirements of you, our customer, with a complete file checking each step from molten steel to finished product. It also means that when you receive a Finkl forging or die block it can be used with confidence. It will do your job and do it well. When you need quality and service specify Finkl forgings and die blocks.

For technical assistance or further information concerning your forging problems, call or write your nearest Finkl District Office.

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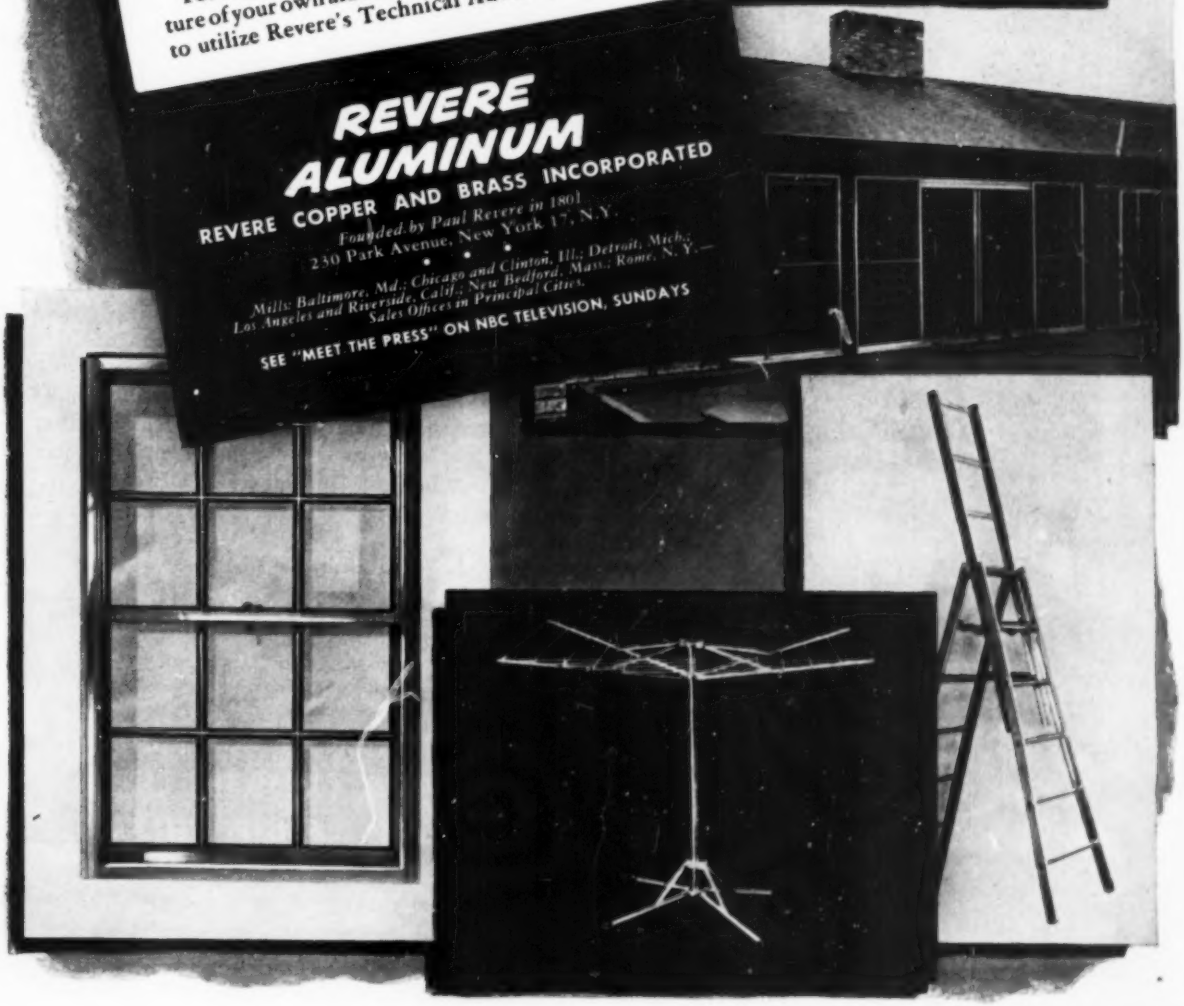

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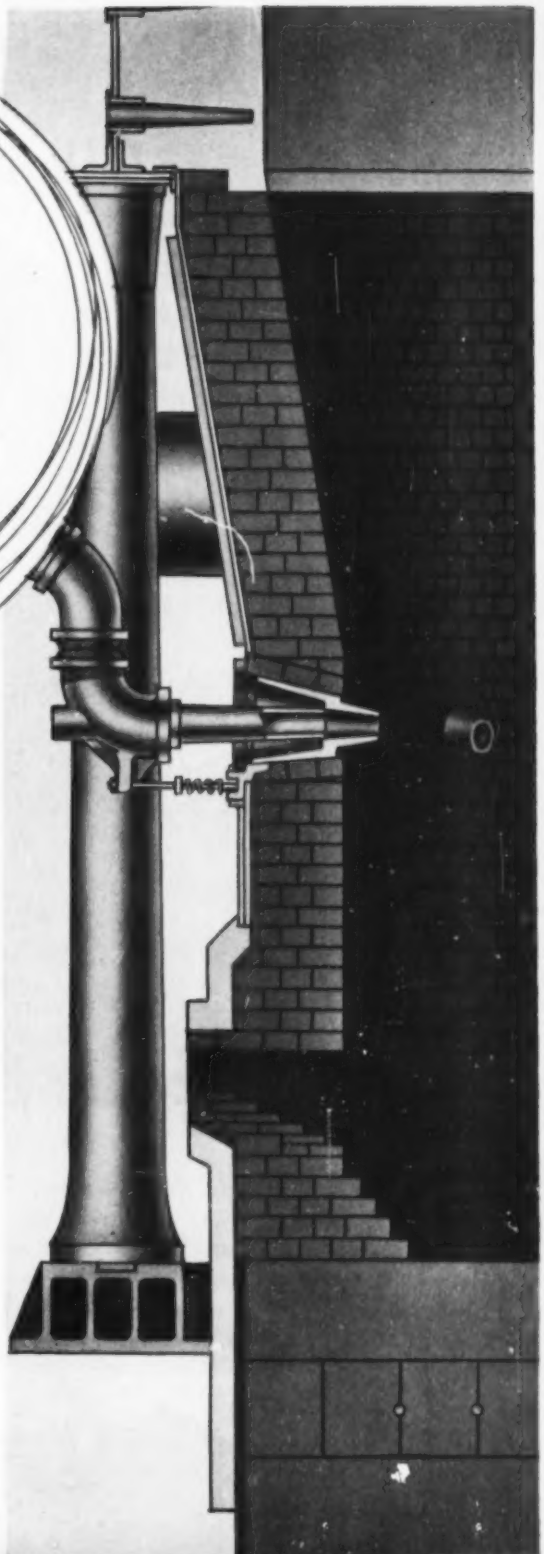

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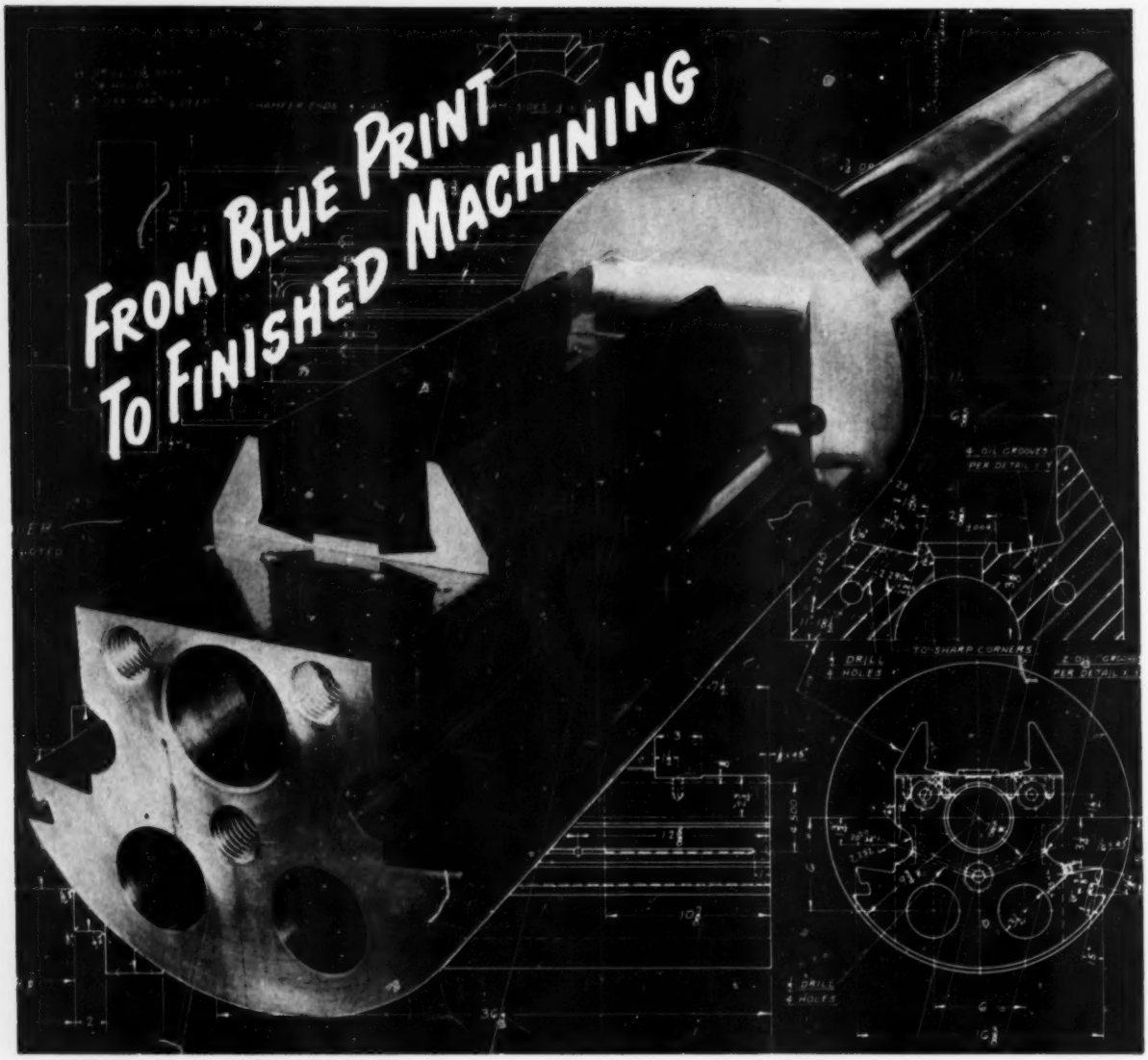

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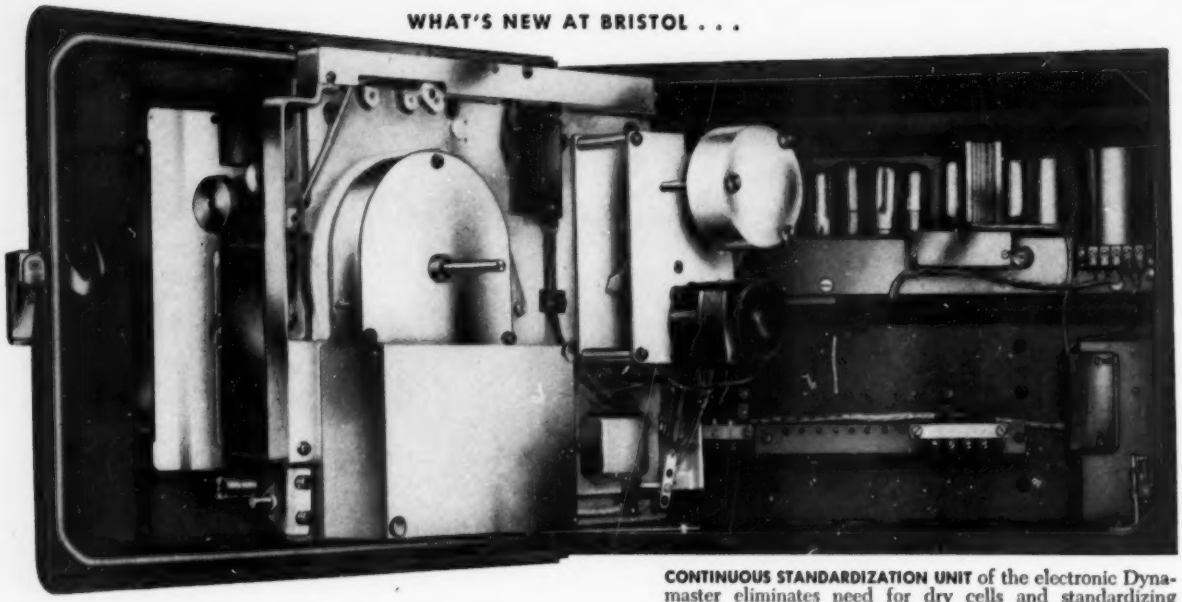

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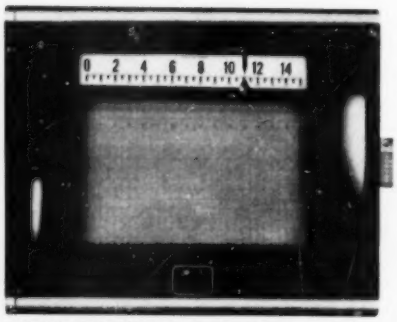
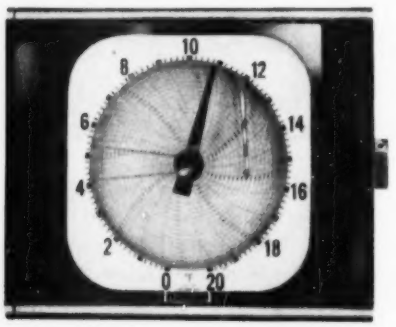


BRISTOL DYNAMASTER CONTROLLERS in either the strip-chart model (shown above) or round-chart model, may be electrically or air operated. 2 position, 3 position, proportional, manual with automatic reset, or proportional input controls. On - off, proportional or reset air controls.



BRISTOL DYNAMASTER RECORDERS come in easy-to-read round-chart (shown here) or strip-chart models. Single record, multiple record or continuous 2 record designs are available. Bristol also supplies all types of time-temperature program controllers.

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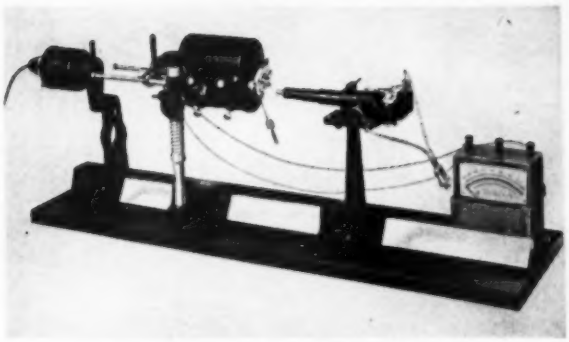

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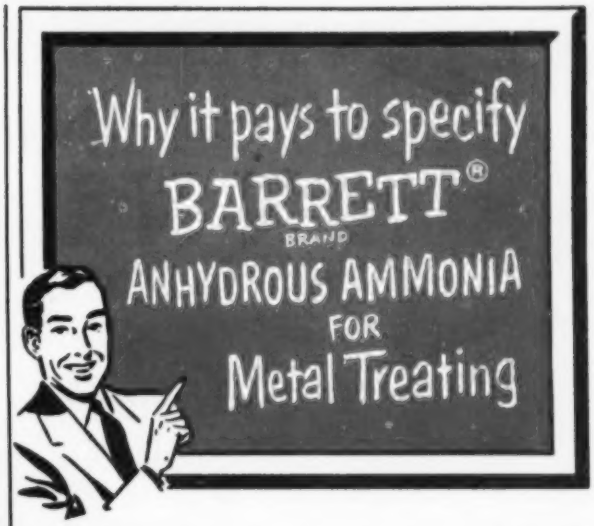

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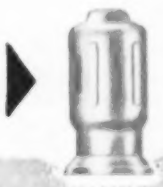

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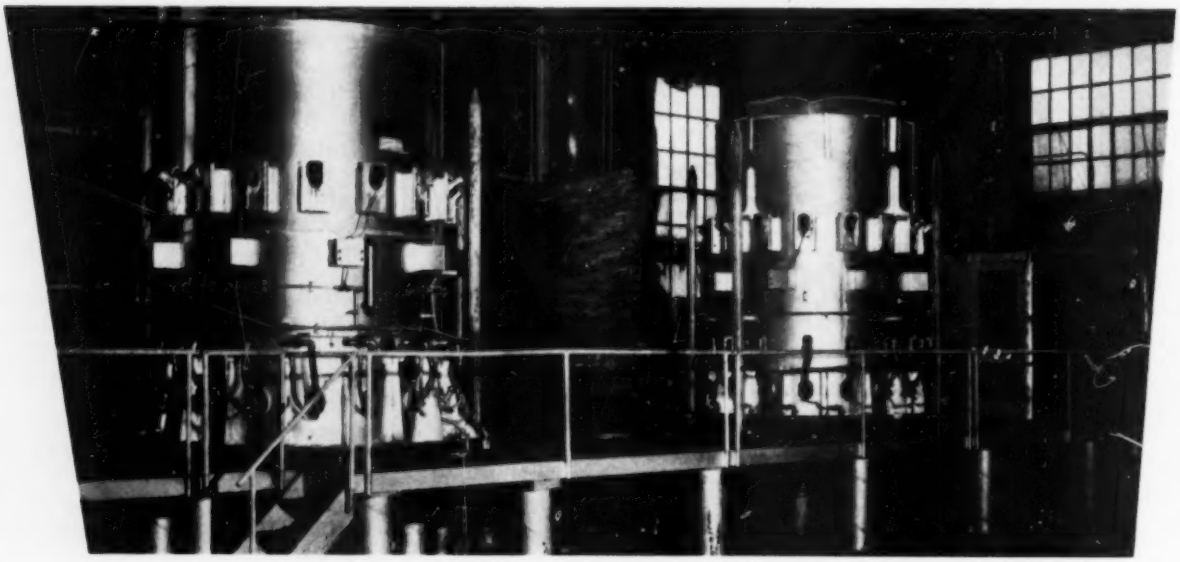

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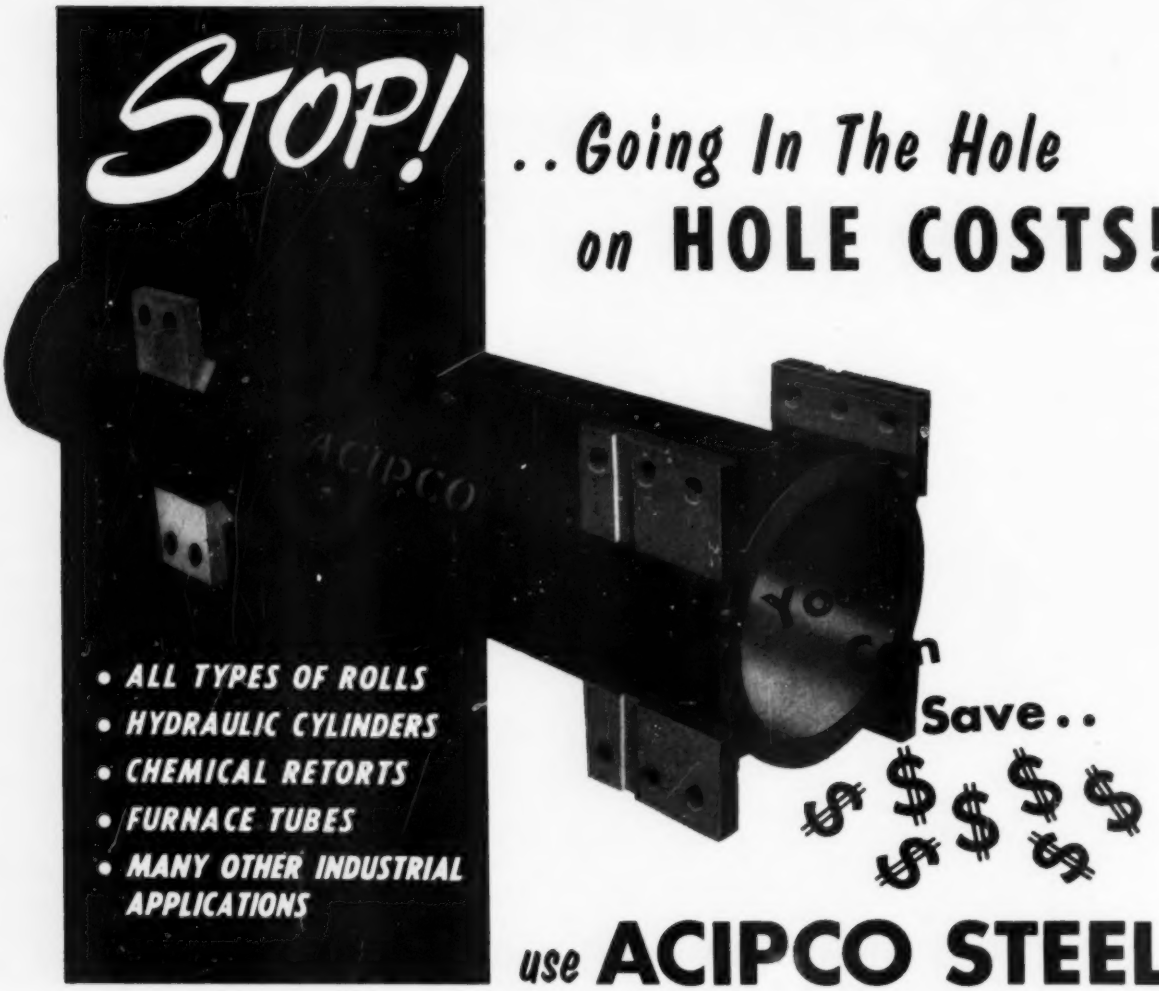

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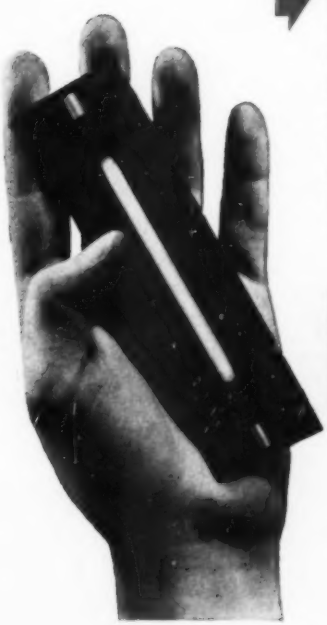

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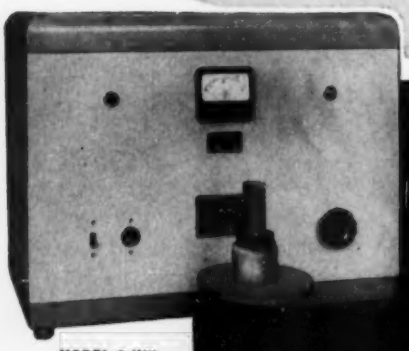

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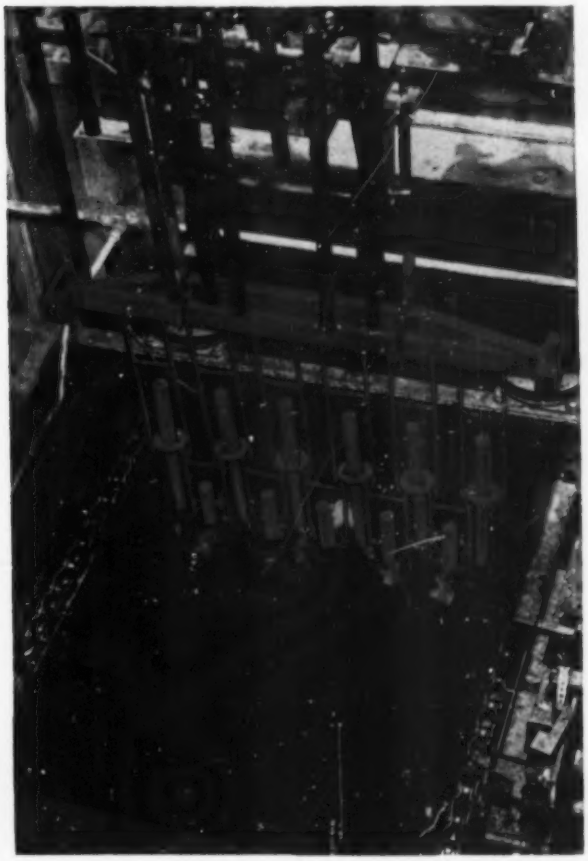
A rack of eleven M1 rifle barrels descending into a tank of Gulf Super-Quench. The rack at the top holds rifle barrels which have just been removed from the quenching oil.



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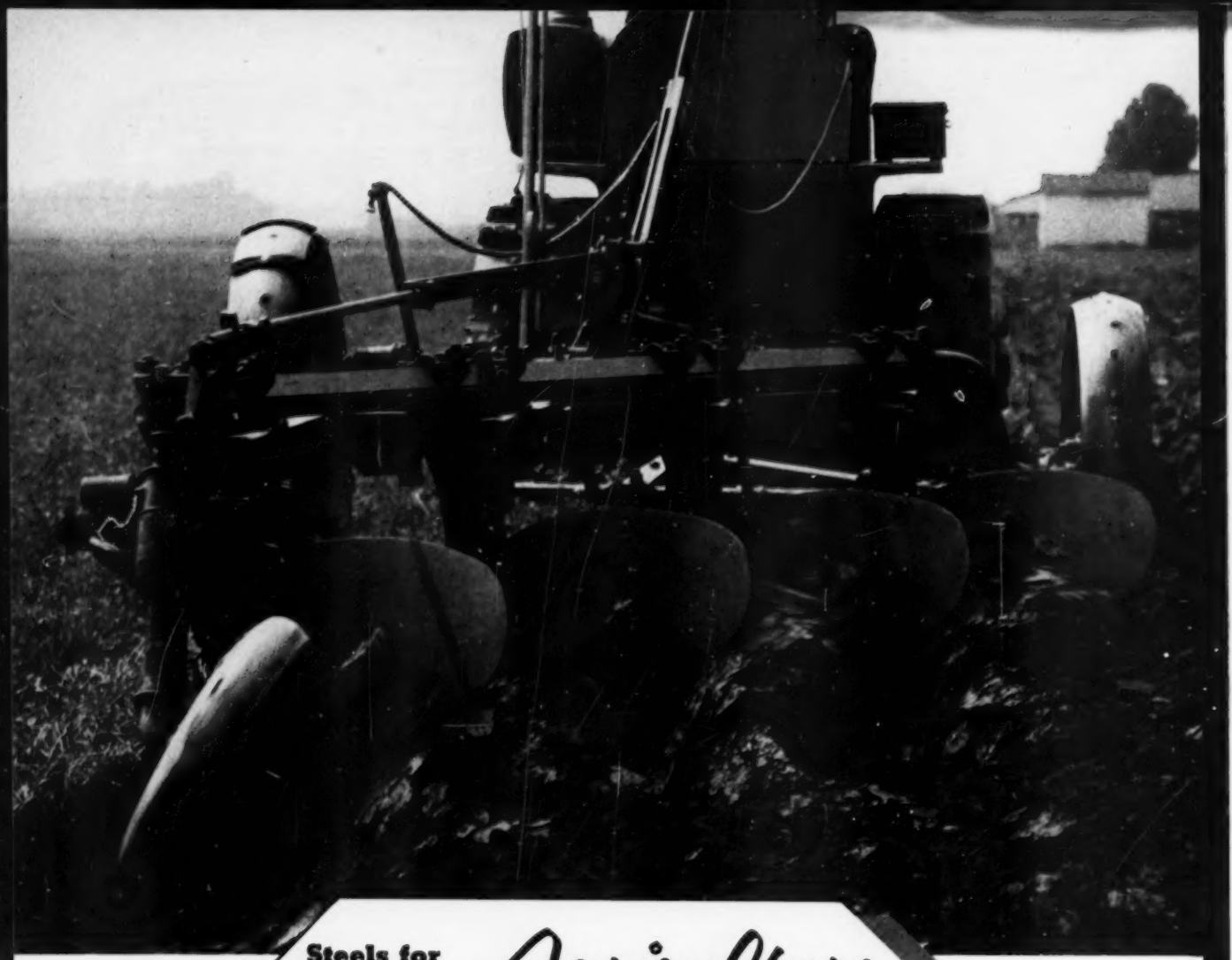

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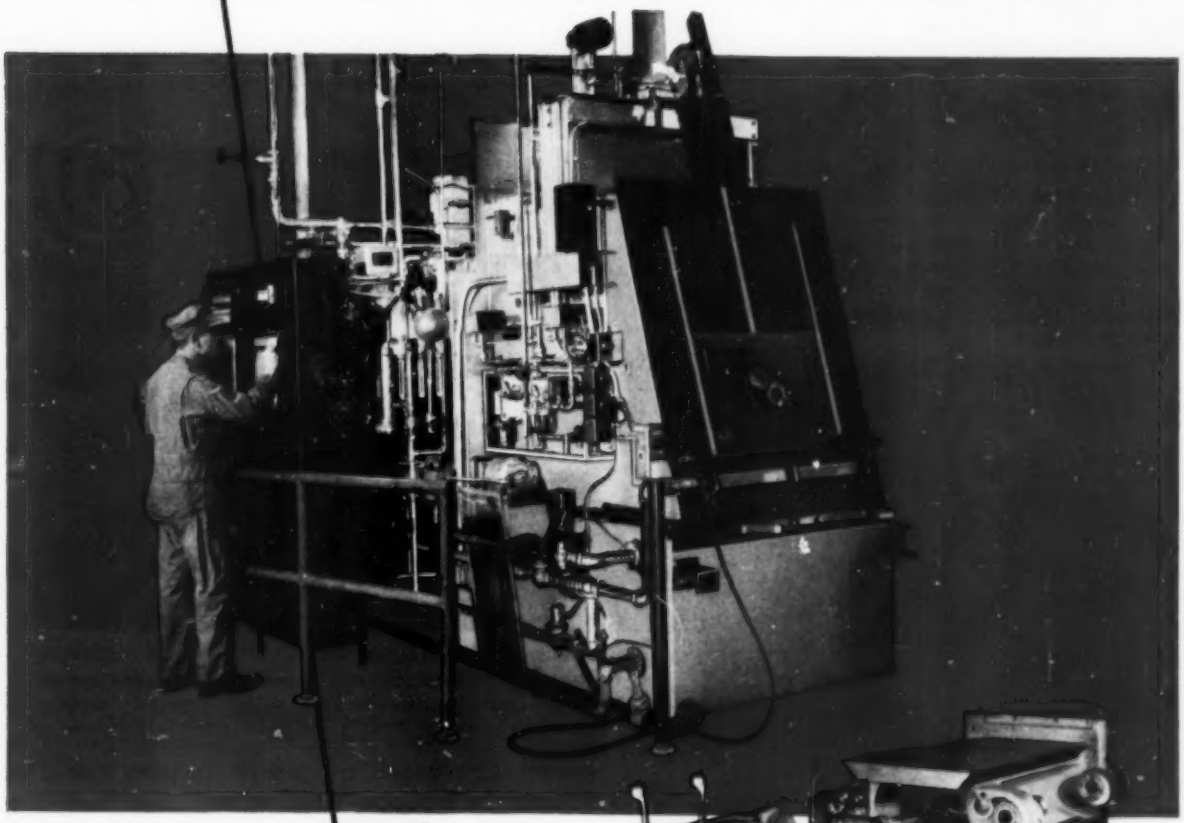
Kearney & Trecker Cuts Gear Carburizing Time 4½ Hours with *LINDBERG* Carbo-nitriding Furnace!



Eight hours! That's how long it formerly took Kearney & Trecker's heat treating department to carburize a 300 pound charge of "secondary feed change cams and gears" to .030 case depth . . by pack carburizing and hardening in pit furnaces.

But now, with a new Lindberg Carbo-nitriding Furnace, K & T heat treaters handle the complete job in only 3½ hours . . a saving of 4½ hours over the old method!

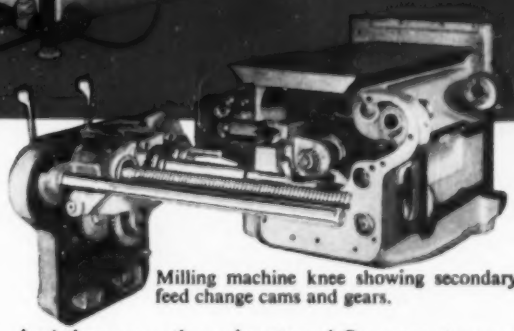
This "before and after" procedure list tells the story:

BEFORE . . . with old box furnace and pit hardening furnace.

1. **Pack parts in box**
2. **Load in carburizing furnace**
3. **Heat to specified temperature**
4. **Remove box from furnace . . . and cool**
5. **Remove cooled parts from box**
6. **Load parts on fixture**
7. **Lower fixture into pit hardening furnace**
8. **Heat to hardening temperature**
9. **Remove heated parts and fixture from work chamber**
10. **Quench in oil**
11. **Remove parts from fixture**

AFTER . . . with new Lindberg Carbo-nitriding Furnace

1. Place parts in open work basket
2. Load baskets and work into Lindberg Carbo-nitriding furnace.
3. The furnace then takes over, carburizing, hardening and quenching the load automatically without use of fixtures



Milling machine knee showing secondary feed change cams and gears.

And there are other advantages! One operator was released for other important work. Greater uniformity was obtained. Core toughness improved because of the lower temperature used.

But the story doesn't end here. K & T uses this same furnace to carbo-nitride screws, nuts, T-bolts and washers (in 40% less time than with wet cyaniding) . . and also to handle the neutral hardening of studs (at pronounced labor savings).

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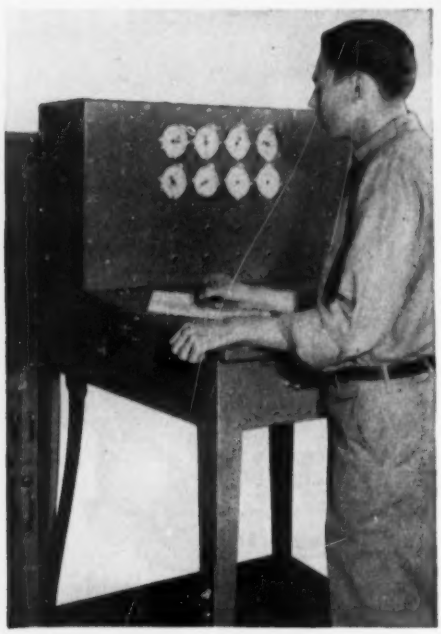
THIS MICROSCOPIC CHECK of your order makes sure that Timken® forging steels have uniform grain size after heat treatment. Result: higher ductility, higher impact. This is another example of the many ways the Timken Company controls quality at every step in production.

INDIVIDUAL HANDLING of your order enables us to target conditioning procedure to your forging requirements. Your forging rejects are minimized. And you save steel because the good dimensional tolerances of Timken bars produce uniform weight multiples with a minimum of steel lost in flashings.



RIGIDLY CONTROLLED CHEMISTRY assures you of uniform composition in every forging bar. This spectrometer, for example, tells the exact composition of a melt in just 40 seconds. Results are flashed back to the furnace so the melter can maintain constant control of the heat analysis.

YOU HAVE FEWER FURNACE ADJUSTMENTS when you use Timken forging steels. Every lot responds uniformly to heat treatment because every lot has the same physical and chemical properties. Always specify Timken forging steels. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

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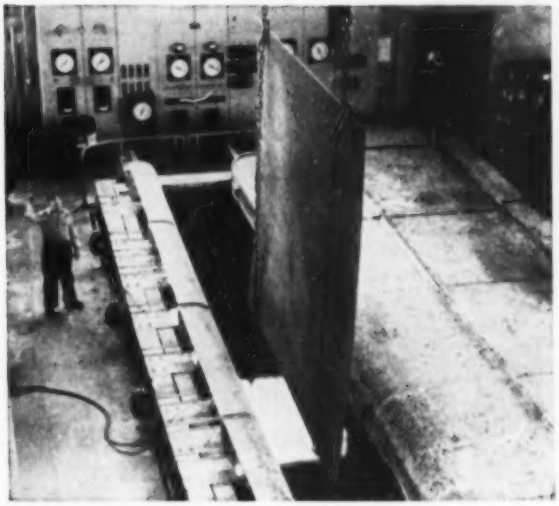

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DU PONT
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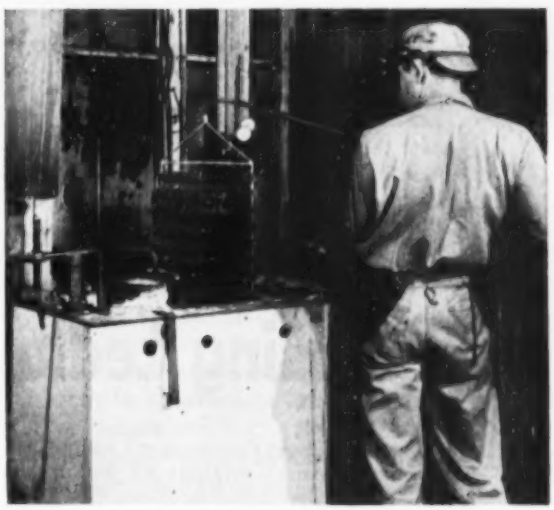

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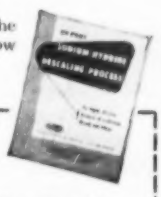

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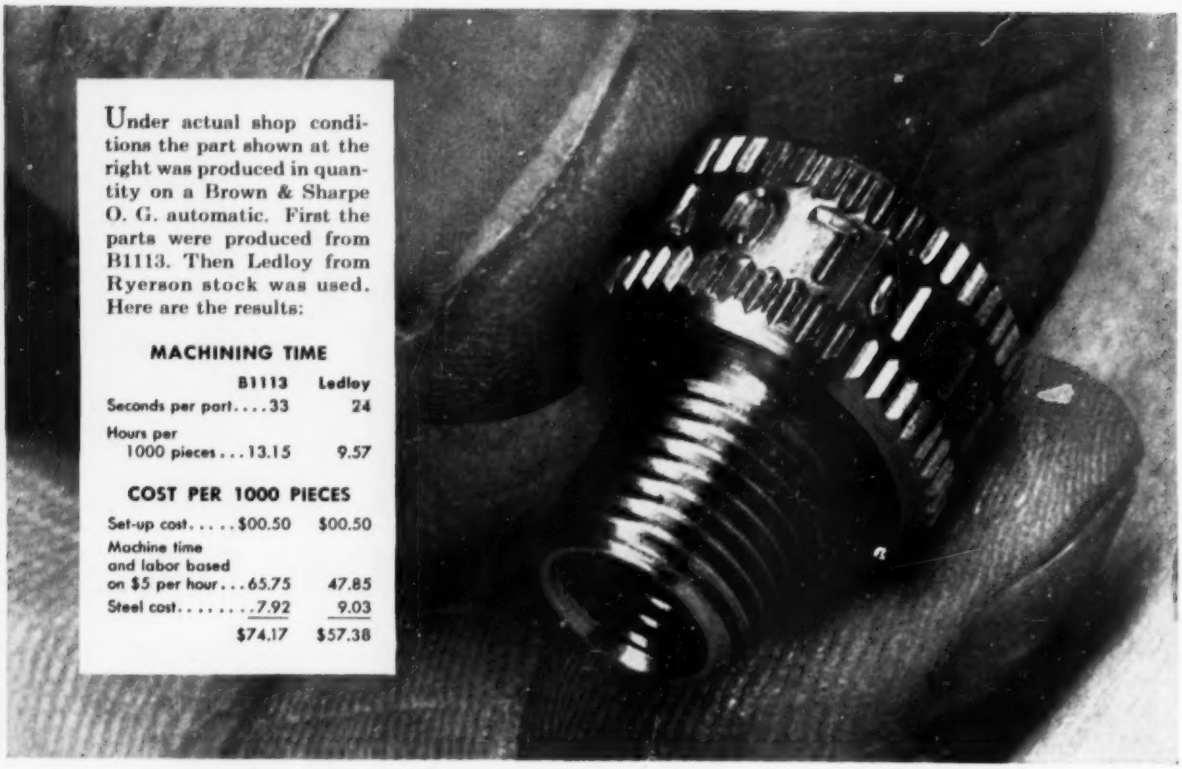

Under actual shop conditions the part shown at the right was produced in quantity on a Brown & Sharpe O. G. automatic. First the parts were produced from B1113. Then Ledloy from Ryerson stock was used. Here are the results:

MACHINING TIME

	B1113	Ledloy
Seconds per part	.33	24
Hours per 1000 pieces	13.15	9.57

COST PER 1000 PIECES

Set-up cost	$00.50	$00.50
Machine time and labor based on $5 per hour	65.75	47.85
Steel cost	7.92	9.03
	$74.17	$57.38

$16.79 saving on 1000 parts using Ledloy from Ryerson

In shops throughout the country Ledloy is effecting similar savings—establishing its superiority over all other free-machining steels. Since switching to Ledloy, one shop reports an increase in production of 54%; another 43%; still another 75%!

On the average, this remarkable lead-lubricated steel brings net savings of 25% or more everywhere it is used by permitting much faster feeds and speeds (25 to 50% faster than B1113) and by extending tool life as much as 200%. Still Ledloy retains the strength and other good qualities of an open hearth steel. Machines to an unusually clean, smooth finish—bends, crimps, swedges or rivets easily.

You can get quick shipment of Ledloy in any quantity from your nearby Ryerson plant. Rounds, squares and hexagons are immediately available in a wide range of sizes. And your Ryerson representative will be glad to give you all the engineering data on this remarkable free-machining steel. We suggest you order a trial quantity now.

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Metallurgist Assesses Impact of New Automatic Control Mechanisms

By ARTHUR H. ALLEN
Special Assignments,
Metal Progress

"STRANGE how many millions of dollars are being spent by industry and government in trying to create a reasonably exact facsimile of a human being!" So remarked a leading engineer to a group of his colleagues recently. He was referring, of course, to the development and interconnection of devices and mechanisms which (literally) see, hear, feel, smell – and even remember – the actions of production processes to control them automatically within specified limits and tolerances.

This "liberation of technology from the limitations of human control", as it has been described, goes under a variety of names. Those most frequently mentioned are automation, automatism, automatic factories, push-button production, robot control. Of a more *haut-monde* nature is cybernetics, defined as the entire "philosophy of the automatic age" as it applies to both machines and men.

For the purposes of this general discussion, confined as it will be to the metals industries and the metallurgists serving them, the label of "automation" will be used. That is the most widely accepted designation to appear thus far. The techniques are not confined to the production, processing and fabrication of metals. They are being studied and applied increasingly throughout all types of manufacturing, including such unrelated activities as soft-drink bottling, can making and filling, textile weaving, oil refining and chemical processing. But the principal interest of the metallurgist and metals engineer must focus on the achievements of automation in the fabrication of metals and the significance thereof, for these advances will figure in an important degree in metallurgical progress over the next ten years.

Automation is a coined word, credited by many to Del S. Harder, vice-president, manufacturing, of Ford Motor Co. In 1940 Mr. Harder was with the Fisher Body Division of General Motors and was keenly interested in the mechanical handling of large stampings from press to press. Thus the word originally was a combination of "automatic" and "motion" to connote automatic transfer of material.

Since then it has come to mean a lot more. One production expert has suggested it might more properly be considered a fusion of "automatic" and "imagination"!

Whatever the derivation, automation now is one of the most talked-about subjects wherever engineers convene. It is applicable to a wide range of operations in the metals field, all the way from steelmaking to final assembly of the finished product; to single machines, to groups of machines and even to a complete manufacturing plant. Basic is a transition from batch output to continuous flow of the product and its components.

A true example of automation, even though it is old enough to be familiar to all engineers, is the automatic screw machine or the turret lathe, in which a cycle of machining operations to shape a single part is carried out automatically. After the job has been tooled properly, manual effort is needed only for loading and unloading the machine; even these elements have more recently been eliminated here and there.

The continuous strip-sheet mill is another excellent version of automation, although the steel

industry has perhaps never been considered in that light. It involves a succession of rolling operations in which speeds of motors driving the rolls are automatically inter-regulated to compensate for the increasing speed of the steel strip as it is gradually thinned down from a slab. Anyone, though, who remembers only a few years back to the hand mills, will immediately recognize that the continuous mill frees all labor of handling metal from the time the cold slab or billet is pushed into the heating furnace until the coil of strip is pushed off the coiler.

The largest advances in automation have occurred in machine shops for mass production. Typical are large transfer-type machine tools which automatically perform hundreds of individual operations on parts as they are moved, mechanically, from one unit of the equipment to the next. In many instances the individual machines are standard types, so disposed on either side of a central conveyer as to advance into the work, poised at the proper points. Electrical interconnection provides the proper sequence of tool spindle action, either singly or in gangs.

Passing from this rather obvious method of labor saving, we can note that methods for controlling a cycle of operations on a single machine tool by punched tape or magnetic tape are in the early stages of development. One such device is a numerically controlled milling machine for finishing large aluminum aircraft forgings of complicated shape. (This project has been carried out under an Air Force contract by the Servomechanisms Laboratory of the Massachusetts Institute of Technology.)

Meanwhile General Electric Co. has been working on a similar idea, using magnetic tape as the "memory" for a program of milling machine operations on jet plane structures. The device – quite expensive, incidentally – is installed on a machine which is run manually through its precise cycle to make a magnetic tape recording of the motions involved. The recording may then be played any number of times to repeat the same machine sequence.

Fig. 1 – Sand Reclamation Department of Escher Wyss Foundry in Zurich, Switzerland. The two men shown (plus an electronics expert and an unloader) take care of all sand handling

WHY AND WHY NOT

Why automation? Well, there are many sound reasons, together with some serious objections. Of first importance is cost reduction, essential to meet steadily rising wage rates and material prices. By cost reduction is meant, not minor savings on the order of 5 to 10%, but rather something like 25 to 50%. Several automation installations in high-volume plants have actually demonstrated savings of such major order.

Along with manufacturing economies are other goals. Among them are improved quality and uniformity of product, elimination of the monotony and fatigue of repetitive work, and reduction of worker hazards involved in many factory operations.

In contrast with the scheme of *mechanical* transfer of work from machine tool to machine tool, which is old,* the more modern concept of automation as a centralized "brain" which *electronically* controls the production of a part from raw material to the shipping dock is, for the present, little more than mental exercise for academicians unfamiliar with the hard realities of the metalworking industry. They take delight in badgering production men for their slowness or unwillingness to march into "full automation".

Among the first to delineate – in printed words – the automatic factory were E. W. Leaver and J. J. Brown, Canadian radar engineers, who in 1946 propounded theories of plugging basic production units together and connecting them to a master electronic control

*The Editor remembers seeing such a line-up in the Waltham Watch Co.'s factory at least 30 years ago and being told that it was installed many years before that.

cabinet which would direct their functioning, supervise inspection of the finished product and keep records of all pertinent data. Of course, many individual steps were, here and there, already more or less automatic – machining, inspection, accounting – but practical engineers read their proposals to link everything together with amused interest and showed little inclination to pursue them any further.

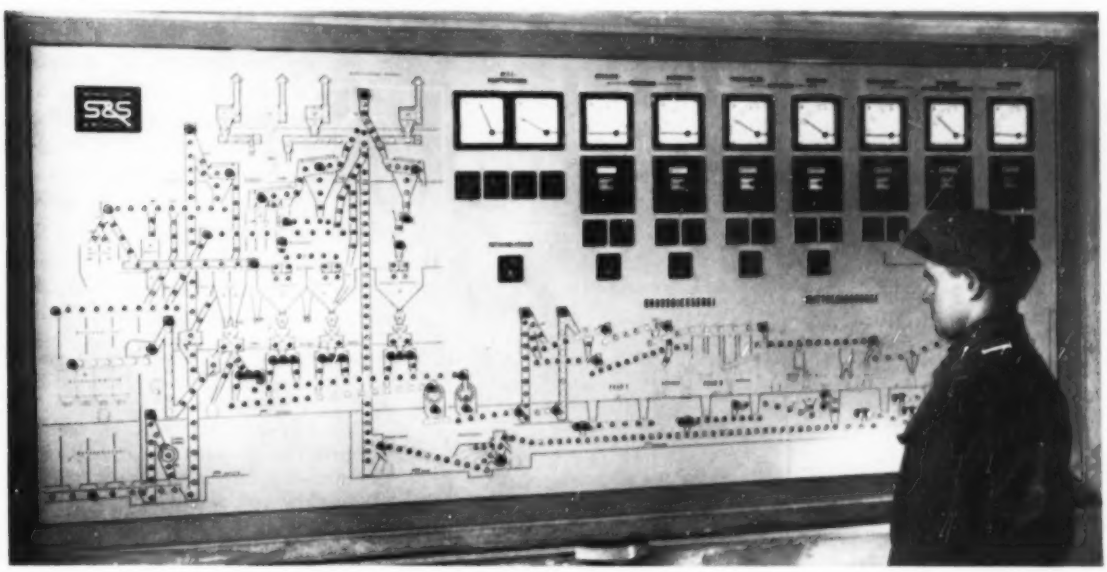
Obstacles to a more general acceptance of automation at the plant level are many, some of them apparently insurmountable without a complete upheaval in product design and processing systems. A problem of first magnitude is the inordinately high cost of the equipment, especially the electronic control devices. Second is inability to handle diversified production in limited quantities. Third is the difficulty of adapting it to finishing operations and to final assembly. Fourth is the high cost of maintenance. Finally must be considered the human and sociological factors, such as the need for higher skills necessary to design and install such a production line and to sustain its operation and the problem of devising workable incentive systems for personnel.

The automobile industry obviously has been a pioneer in adopting automatic equipment. In a real sense Henry Ford's ideas on mass production were first steps toward automation. Unrelenting pressure on costs could be met only by the higher productivity realized from automatic operations. Output of identical parts in great number also was an important consideration.

Among the car builders in recent years, Ford Motor Co. has again led the rest, although none has ignored the possibilities offered. Under Mr. Harder's direction Ford organized an automation department in 1947, to work closely with tool and die designers, plant layout engineers, materials handling specialists, metallurgical and quality control staffs, and management representatives from all levels. Early work had to do with rearrangement of standard machines, connecting them by mechanical devices so that inherent delays caused by manual handling would be eliminated. Later, complete new plants were designed from the ground up around principles of automation, not only in respect to the parts being produced but also in the handling and disposal of process scrap.

Three of the best examples of these almost-complete automations are the Cleveland Engine Plant, the Cleveland Foundry and the Buffalo Stamping Plant. In the engine plant the automatic phases are confined mainly to machining of cylinder blocks and heads. In this department, 40 automatic processes and 80 transfer units are tied together to perform 530 broaching, milling, drilling, reaming and tapping operations. Production rate is 154 engines an hour, a schedule which under former practice, required 117 men to handle machining of blocks alone, but now calls for only 41. Of the latter, 29 are machine setters whose sole job is to change worn tools. The front cover of this issue of *Metal*

Fig. 2 – Central Control Panel for Sand Reclamation Department Shown in Fig. 1



Progress (obtained by courtesy of the Heald Machine Co. and Ford Motor Co.) shows one of the line-ups, a 12-station, fully automatic machine line which drills, bores and reams valve-guide holes and generates valve-seat surfaces in cylinder heads for 6-cylinder overhead-valve engines. All machine cycles, together with movement of parts from one station to the next, are controlled electrically through the panel or console in the right foreground. Production rate averages 90 per hr., although the line has a potential of 120.

In Ford Motor Co.'s Cleveland foundry, a high degree of synchronization and automatic materials handling has been effected, to the end that manpower requirements are at a minimum and working conditions are better than anything yet devised. Movement of sand through pipelines by compressed air over comparatively long distances is just one of the many innovations.* Fast and accurate control of metal composition in the Ford foundry was described in the February issue of *Metal Progress*, p. 87.

In Ford's Buffalo stamping division, 15 press lines have been equipped with devices to handle stampings from one press to the next in the line, entirely without manual assistance. They are unusual in being portable and can be moved out of the line for repairs without interrupting press operations.

A further noteworthy installation of Ford automation equipment handles production of coil springs at a rate of over 4000 pieces per day (in excess of that for any comparable set-up) and with a 50% reduction in manpower. The basic line includes a rod furnace for heating prior to coiling, a group of roll formers for flattening rod ends, hot roll coilers, quench tanks, draw furnaces and shot-blast cleaning machines. Coiling speed is high enough so the springs may be quenched directly without reheating.

Preventive Maintenance – The high maintenance cost of such automation is acknowledged but while the ratio of maintenance cost to direct labor is increased sharply, the maintenance charge per unit of production is actually lower than formerly. One answer to this problem is effective *preventive* maintenance, and it is in this area that the metallurgist is able to make his most important contributions to the success of automation. Preventive maintenance requires keeping accurate records of the expected life of perishable parts, such as cutting tools, and replacing them before failure. Such life expectancies usually are based upon standards developed after review of long periods of operation. They cover not only tools, but also methods and specifications, equipment and materials.

Such things as metallurgical checks on incoming materials, studies of tool failures and tool wear, and analyses of rejects, provide valuable data for collation into sound standards. This has been proved – again with the automotive industry taking the lead – in electrical, hydraulic, lubrication and pneumatic apparatus standards evolved by the Joint Industry Conference method, in which representatives of both users and suppliers, together with certain trade associations, collaborated. These Joint Industry Conference standards have been widely approved and accepted by all parties concerned.

SEMI-AUTOMATION

Installations which might best be described as semi-automation are numerous throughout the automotive industry. The De Soto engine plant is typical of ingenious coordination of overhead chain conveyers with transfer-type machine tools, all connected to a centralized control console or automatic dispatcher. A conveyer of generous capacity can double as a storage facility for material in process – always a troublesome matter in automatic processing.

Press forging of crankshafts is handled continuously in a new layout designed by the Dodge Division of Chrysler Corp., as described in *Metal Progress* for February 1953, p. 90. Savings of 25% of the costs in previous methods were realized, along with a tripled production rate in less floor area. Steps include billet heating, preforming, pressing, trimming, air cooling on conveyer, heating, quenching, drawing and straightening. All operations are sequenced and interlocked electrically. Complex electronic control equipment and the 11 miles of wiring neces-

*Editor's Footnote – Europeans also have some good examples of automation. During a visit last summer at the Escher Wyss foundry in Zurich, Switzerland, where a large variety of castings is made, ranging from small malleable brackets to massive hydraulic turbine casings, a complete sand reclamation and handling system was observed which requires the services of four men only – one on the track where carloads of new sand were unloaded, two in the room where sands were weighed for blending in mullers (see Fig. 1, p. 66), and one electronic expert for trouble shooting.

In this system, conveyers, chutes, bin gates, and elevators, together with synchronization, interlocks and safety devices, were operated by remote program control, all the way from shake-out screen through to overhead bins above each molding machine or sandslinger area. The central control panel is shown in Fig. 2 on p. 67.

sary to tie it into the various production machines contributed to the $30 million cost of the installation, yet it is expected to pay for itself in a couple of years!

The problem of introducing automation into final assembly is a tough one. Both users and designers of equipment scoff at the idea that it could ever be worked out economically for something as complex as, say, an automobile engine. Still, there are instances of a degree of success in certain smaller parts. One of the General Motors divisions, for example, brings together an assembly of stampings, rivets, gaskets and springs and fits them together into a radiator cap which is further inspected automatically before shipment – all without the need for assemblers in the accepted sense.

The completely automatic manufacturing plant still is some distance in the future, in the practical viewpoint of Mr. Harder of Ford. He takes the conservative slant that the automation which has been achieved is evolutionary rather than revolutionary, and represents maturity of manufacturing methods. Maturity results from a combination of the best engineering planning and the greater utilization of specialists in the operating staff. He does not deny that the trend will continue, concluding that the future of automatic processes is inseparable from the future of the manufacturing industries in the constant fight to reduce costs so that consumption of goods may be on a broader base.

He will get little argument over these contentions.

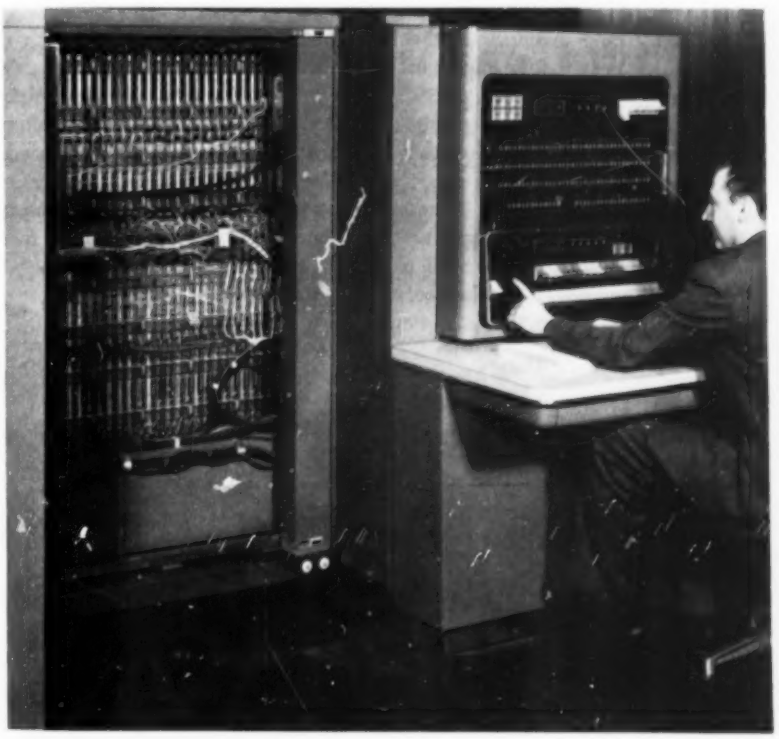
LIMITED PRODUCTION

Most of the doubt arises over the question of whether automation costs can be justified for limited production schedules. Few of the 12,000-odd plants in the metals industries operate at a volume anywhere near the automotive level. Their managers concede the economies somebody else may realize on a higher volume; they are not convinced yet of the possibilities in their own scheme of things, despite powerful persuasive pressure from automakers trying to whittle down the costs of purchased parts.

C. F. Hautau, an exponent of automatic handling and an engineer schooled in today's manufacturing methods, thinks that there may be unexplored opportunities for the producers of "discrete" quantities. He cites an airplane engine manufacturer who sought to boost production from 95 to 400 units a month. The old system assembled the 28,000 parts into one engine on a moving conveyer, starting with a 35-lb. casting and building it up to a finished unit weighing 3800 lb., all of it held in position by a fixture weighing 5000 lb.

Studies showed it would be much easier and faster to assemble the engines as they pause at fixed stations, thus breaking up the entire series of operations into basic groups, each functioning on a predetermined time cycle. Many other ideas were incorporated into the redesigned sys-

Fig. 3 – A Robot Something Like IBM'S "Electronic Data Processing Machine" (Now Used Primarily for Complex Arithmetical Computations) Will Probably Be the Heart of the Automatic Factory of the Future. Shown below is the control center of the machine, with the computing section open, revealing part of its intricate wiring. Magnetic tapes introduce and record data at the rate of 12,500 digits per sec.



tem, too complicated to be detailed here. The upshot was that a production rate far in excess of 400 units a month was realized, and in a floor area only 1/16 of that which would have been demanded by the original method.

This borders on what John Diebold, a prolific writer on the subject of automation, chooses to call his "bundles of functions" concept. He reasons that in many fabricating operations a clearly definable group of functions is performed upon a related group of products. For instance, a series of turning operations may be followed by a series of drilling steps. If each series could be performed at the same time in the same machine, a saving in machining time and equipment cost would result.

"Feedback" — One essential of successful automation, as Diebold sees it, is "feedback" through electronic controls on a machine for the self-correction of errors in its fuctioning. At this point the subject seems to leap away from the practical level and only confounds the engineer whose everyday job is to make a product at a define cost and rate. Into Diebold's picture come open-loop and closed-loop control systems, sensory mechanisms, servomechanisms, "effectors", digital and analogue computers, overshooting and undershooting, plus several other strange terms. The interested reader or advanced student can pursue such matters for many long evenings in the large literature, of which only a few important items are cited in the bibliography on p. 168.

Feedback, as it occurs in closed-loop control systems, becomes a function of the *actual* performance of the machine on which the system is installed, rather than its *expected* performance. This means that no correct cycling time need be predetermined. The human use of tools and machines which, in themselves, have only simple open-loop controls, depends upon a closed-loop system—namely, the human muscular and nervous system. Transfer of this ability to electronic equipment and to servomechanisms thus becomes the working area of the automatist.

Military demands of the last war, like gun directors, range finders and flight predictors, gave the greatest impetus to the design of servo systems. They are now being studied intensively for industrial applications, particularly by such firms as International Business Machines and Remington-Rand, although admittedly very few pieces of such equipment are yet in use.

The delicacy and fragility of complex electronic control equipment are looked upon with suspicion by many machinery builders and plant operators; electrical relays are preferred because they are more rugged. The magnetic amplifier may work out to be a more rugged substitute for electronic tubes where service conditions are severe. However, the speed and versatility of electronic devices, coupled with the progress inevitably to be made in their design and construction, will change this situation. Builders of a wide variety of control devices are banking on this. A gage manufacturer says it is essential to close the gap between gaging a part in process and feeding back information to the machine input, so the tools can immediately be brought back to the center of tolerance and gradual drift be avoided.

The vast and entirely new requirements of atomic energy research and production have been another spur to advanced methods of automatic handling and processing. In some places it is necessary if for no other reason than to insure safety of operating personnel from dangerous radioactivity. In others, as in the diffusion plants for separating the isotopes of uranium, there are simply acres of operating floors without a single operator. It must be recognized of course that in this field, as in few others, the element of cost has been secondary, but again, full automation is doubtless responsible for much of the notable drop in unit costs recently reported by the U.S. Atomic Energy Commission.

The dearth of design engineers capable of assimilating the advanced mathematics of highly complex processes and control systems is a disturbing factor. More automation will mean a stepped-up demand for good engineers. Concurrently, more engineers will have to be elevated to management positions, accentuating the present shortage of personnel at the planning and operating level.

SUMMARY

Throughout the metals industries, whether it be for production, processing, heat treatment or inspection, an accelerating trend is observable toward the use of electronic devices for sensing the precision of operating and "feeding back" such information to the equipment for self-correction of errors. Deterrents to more rapid progress are the high cost of control mechanisms and the in-born suspicion or lack of understanding of their functioning on the part of management and production planners unfamiliar with the new techniques.

(*Continued on p.* 168)

Design and Construction of Needle Thermocouples

By W. GERARD RAUCH, Associate Metallurgical Engineer
Metallurgy Div., Argonne National Laboratory, Lemont, Ill.

CERTAIN difficulties often arise in attempts to use standard two-wire thermocouples to measure and record the temperatures of various components of complex heated systems. Such couples require that the two wires be insulated from each other (except at the sensing tip) and that the assembly be enclosed in an impervious metal or ceramic protection tube. Such couples are bulky, somewhat fragile and inflexible, difficult to insert into a confined space, and to bring out through a tortuous path.

Many of these difficulties are overcome in the needle-type thermocouples; these consist of an insulated wire representing one component, which is inserted into a tube, representing the second component, the hot junction between rod and tube being formed by welding. They can be made quite small in diameter by using hypodermic needle tubing and fine wire inserts, the insulation being held in place by the tube itself and the tube serving as its own protection. Because of their flexibility and small size, these couples can be threaded through small and winding passageways.

Since the tube component of the couple serves as its own protection tube, it should be resistant to attack or deterioration by the environment in which it is to be used. However, not all metals which satisfy this requirement can be obtained in the form of small-diameter hypodermic needle tubing. The insulation must be of such nature that it can be applied to a fine wire, should be flexible, and should be resistant to thermal, mechanical, and other types of damage; also, the couple combination should have large thermo-electric power, small mass and low heat capacity. The couple should have good reproducibility of electromotive force upon repeated heating and cooling and should be resistant to mechanical damage by thermal cycling.

PRINCIPLES OF DESIGN AND ASSEMBLY

The construction of a thermocouple of this kind (shown in Fig. 1) consists of inserting an insulated wire into a small diameter tube of the hypodermic needle type, and drawing (sinking) the tube through a die on a drawbench, thereby tightly gripping and sealing the wire within the tube. In some instances needle tubing of certain

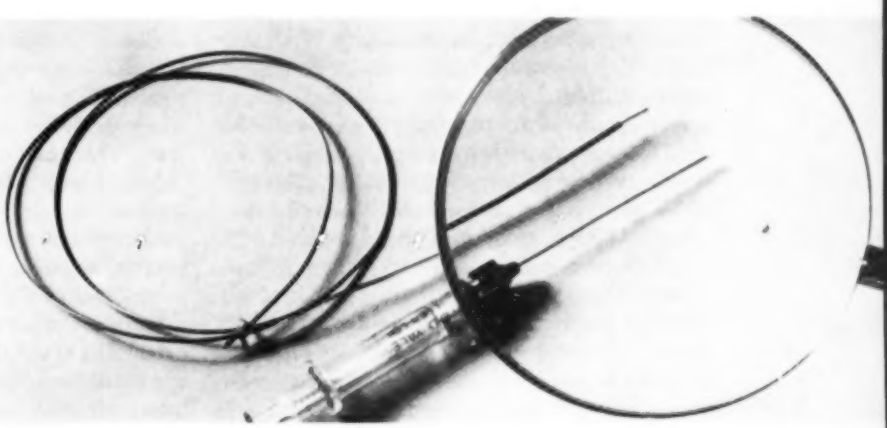


Fig. 1 — Size of "Needle" Thermocouple Compared to a Standard Hypodermic Needle of 0.025 In. O.D. The magnified portion shows the lead end of a 0.040-in. o.d. Inconel thermocouple tube into which a 0.015-in. constantan wire has been inserted through its entire length. Couples of any length are possible, but those produced at Argonne have been limited to 20 ft. (Photo courtesy of Argonne National Laboratory)

materials was available in diameters that were small enough to eliminate the drawbench operation; the drawing operation always carried the hazard of breaking the insulation by pinching it too tightly between wire and tube. The tube and wire, being of dissimilar metals, comprise the couple components. A hot junction is obtained by fusion of the wire and tubing at one end; another function of fusion is to seal off one end of the thermocouple.

The primary intention was to utilize commercially available materials, with strong consideration given to selection of tubing that was resistant to attack by air and alkali metals. Nickel, stainless steel and Inconel tubing, because of their good corrosion resistance and availability, have served principally for the tubing. Different wire materials and electrical insulations were "fitted" in various combinations to these tubes.

Of the different wire insulations tested for their ability to resist deterioration at 1110° F., baked-on paint coatings of the kind commonly called enamel (applied on copper and constantan wire) were the least durable, showing rapid decay above 480° F. Single-thickness insulations of glass fiber were satisfactory up to 930° F. A double thickness of glass fiber, impregnated with a silicone resin, proved satisfactory for use at temperatures up to 1110° F. A five-cycle heating-cooling test extending over two weeks on a constantan wire covered with the latter insulation caused no deterioration of the insulation. No advantage was noted in the use of triple layers of spun glass insulation on the basis of its appearance after repeated heating to 1110° F.; in addition the material was not readily available at the time of this investigation. Of special interest is "Vitrotex", an insulating material for application only on copper wire; this product (of the Anaconda Wire and Cable Co.) is essentially a multiple glass fiber wrapping, coated with a silicone enamel binder, and heat treated. Its plasticity was remarkably good after repeated heating cycles to 1110° F. The thermocouples were individually calibrated against a standard chromel-alumel couple and subjected to repeated heating and cooling.

The thermocouples, described in the text that follows, consist of needle tubing of selected materials ranging in size from 0.040 to 0.090 in. outside diameter with an inside diameter of 0.020 in. or larger. A small-diameter wire corresponding to 30 gage (approximately 0.015 in., including insulation) was selected to permit the assembly of long lengths.

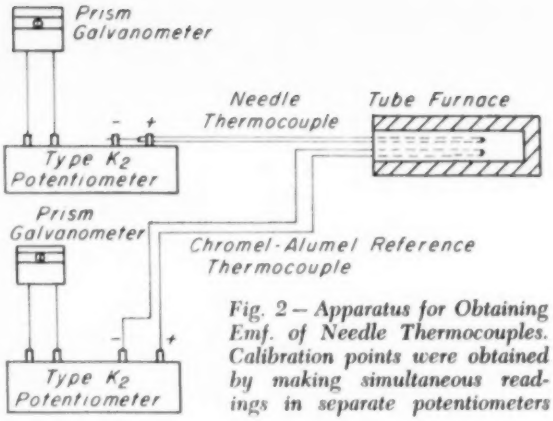


Fig. 2 – Apparatus for Obtaining Emf. of Needle Thermocouples. Calibration points were obtained by making simultaneous readings in separate potentiometers

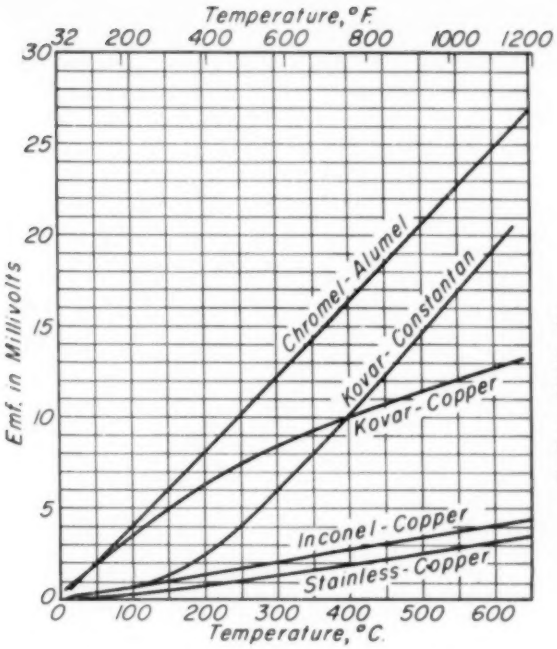
Calibration and Testing – The various couples constructed during this study were calibrated against a standard chromel-alumel couple using the apparatus shown in Fig. 2. The hot junctions of both the standard and needle couples were placed close together in a tube furnace. Simultaneous measurements of couple potentials were made on separate potentiometers. The reference junction (not shown in Fig. 2) was an ice bath at 32° F. Calibration data for these couples are plotted in Fig. 3.

RESULTS

Stainless Steel-Aluminum – The first combination to be studied was a stainless steel-aluminum couple using a 0.030-in. 2 S aluminum wire as insert. The wire was anodized 0.003 to 0.006 in. deep to produce a nonconducting insulation against the stainless steel tubing. This coating has not proved satisfactory, since the poor adhesion of the anodized layer is aggravated by severe abrasion when a long length of wire is pulled through the tubing. Short circuiting occurred during several of these assembly attempts even before calibration.

Stainless Steel-Copper – Type 316 stainless steel (0.084 in. o.d., 0.030 in. i.d., 9 ft. long) was used with copper wire covered with "Vitrotex". This thermocouple assembly was not drawn down. The calibration of this type of couple exhibited the lowest thermo-electric power of the series studied. The internal resistance was 35 to 37 ohms. The calibration data are plotted in Fig. 3.

Inconel-Copper – Inconel tubing (0.073 in. o.d., 10 ft. long) was used in combination with a copper wire insulated with "Vitrotex". The tubing with the inserted wire was swaged down



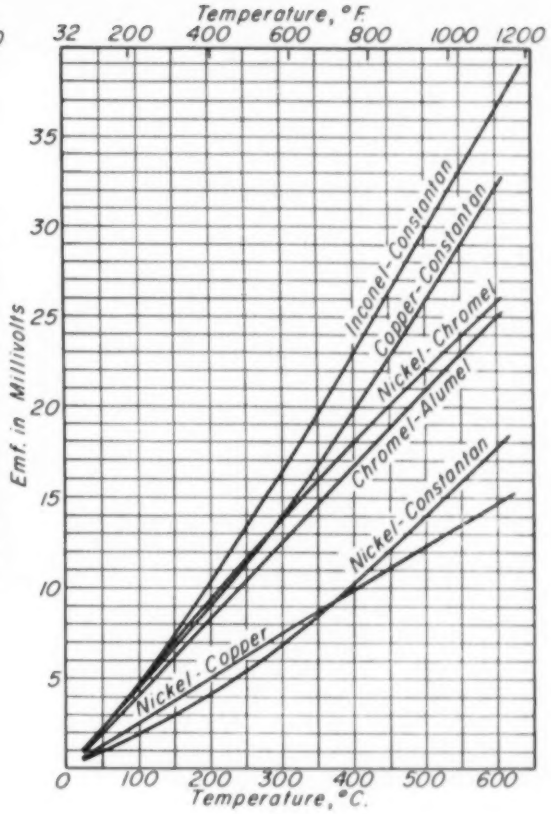


Fig. 3 – Calibration Curves for Combinations Used in Needle Thermocouples Compared With Curve for Chromel-Alumel Couple. Reference junction at 32° F.

at one end to provide an adequate point to start a drawing operation. A single draw was made to 0.064 in. o.d., using a standard tungsten carbide wire die and colloidal graphite as lubricant. The emf. generated with this combination was found to be very low and of erratic response in recalibration. Internal resistance of the thermocouple was approximately 40 ohms.

Kovar-Copper – For this combination the Kovar tubing (54% iron, 28% nickel, 18% cobalt) was 0.040 in. o.d. having a wall thickness of 0.009 in., and the wire insert was a 30-gage copper wire, "Vitrotex"-coated. The tube assembly was put through a sizing die to relieve the coiling tendency of the 12-ft. long tubing. Internal resistance of the couple after calibration was 46 ohms. A bowed calibration curve and relatively low emf. were obtained for this couple combination.

Kovar-Constantan – Tubing for this combination was of the same kind and size as for the preceding thermocouple, the insert being a 30-gage wire of constantan (an alloy of about 60% copper and 40% nickel). The wire insulation was a double layer of spun glass and a wrapping treated with silicone oil. Drawbench facilities were utilized here also to combat coiling of the thin 12-ft. long tubing. Calibration was made up to 1175° F. and two heating-cooling cycles were applied. Internal resistance was 40 to 45 ohms.

Nickel-Constantan – Tubing of grade A nickel (8½ ft. long, 0.090 in. o.d. and 0.020 in. wall thickness) was used in conjunction with 30-gage constantan wire which was insulated as the previous combination. This tube assembly was drawn down in succession through 0.078, 0.068, 0.058 and 0.048-in. dies at a speed of about 12 in. per min. using colloidal graphite as lubricant. Direct reduction, as attempted through the final 0.048-in. die, left the assembly twisted and impossible to straighten. This thermocouple generated only a relatively low thermo-electric force at 1110° F. Internal resistance was approximately 40 ohms.

Nickel-Copper – Grade A nickel for the tube (0.074 in. o.d., 0.020 in. wall thickness), and "Vitrotex"-insulated 30-gage copper wire were used for this combination. A 10-ft. long thermocouple was assembled and calibrated, the needle couple, prior to calibration, being pulled through a sizing die to prevent twisting. The generated emf. was nearly proportional to temperature, and the couple held its calibration

Inconel-Constantan for High Emf.

during several heating and cooling cycles. Internal resistance measured 45 to 48 ohms.

Nickel-Chromel – To investigate the emf. properties of chromel versus nickel, a thermocouple was made of wire for each of the components instead of the tubing-wire construction. This was necessary because the inadequate insulation of the chromel wire made it unsuitable for direct insertion into the nickel tubing. The wires were separated in the conventional manner by silimanite beads. The emf. was satisfactorily reproducible and slightly higher than that of the standard chromel-alumel couple.

Copper-Constantan – Here again hypodermic needle-type tubing was used, the tube being of oxygen-free high-conductivity copper. The constantan wire was 30 gage and insulated with a double layer of spun glass. The tube assembly was 8 ft. long. The outside diameter of the copper tubing (0.090 in.) was reduced prior to wire insertion in one pass through a 0.058-in. wire die without encountering the curling effect observed in other tubing, notably nickel. Calibration was made up to 1130° F. and the couple was subjected to two heating-cooling cycles. The tubing tarnished badly at higher temperatures, giving an erratic emf.

Inconel-Constantan – In attempts to develop a needle thermocouple with higher than average electromotive power, Inconel versus constantan has proved to be a most desirable choice. Not only was a high emf. produced (36.59 millivolts at 1110° F. as compared with 24.97 millivolts at the same temperature for a chromel-alumel couple), but the reading was consistently reproducible for six consecutive heating-cooling cycles. Calibration was performed against a chromel-alumel thermocouple for temperatures up to 1110° F.

The construction and assembly procedure remained essentially identical with that used for other thermocouples investigated. The Inconel tubing, in 10 to 12-ft. lengths, was 0.076 in. o.d. and had 0.014-in. wall thickness. The constantan wire insert was 30 gage and was insulated with double or triple layers of spun glass and silicone-treated wrapping materials. For extension leads to remote instruments, Inconel wire was soldered to the tubing assembly. This avoided extraneous emf. at the reference junction and limited otherwise necessary compensations within the circuit. The internal resistance of this couple, including lead wires, was 68 to 70 ohms.

Since this couple has a rather large thermoelectric power the possibility of its use for measurements at moderately low temperatures was investigated. Four Inconel-constantan thermocouples were constructed and calibrated in pairs against a full-immersion mercury thermometer in the range of 50 to 160° F. An oil bath equipped with an immersion heater and stirrer was used for calibrating these couples. Two potentiometers coupled to prism galvanometers were used to measure the potential of the couples. The calibration data for these four couples are plotted in Fig. 4.

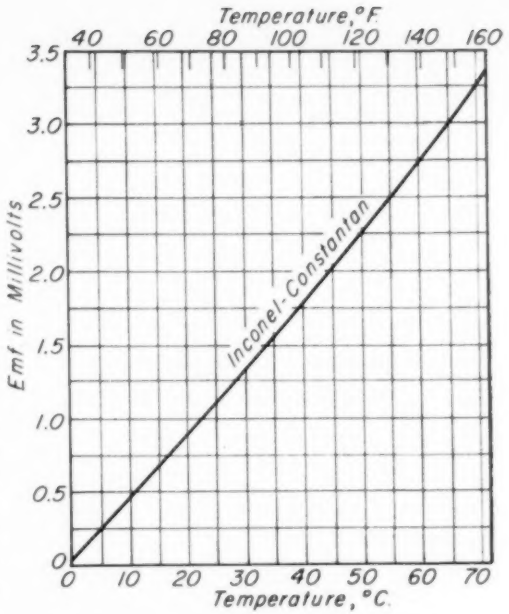
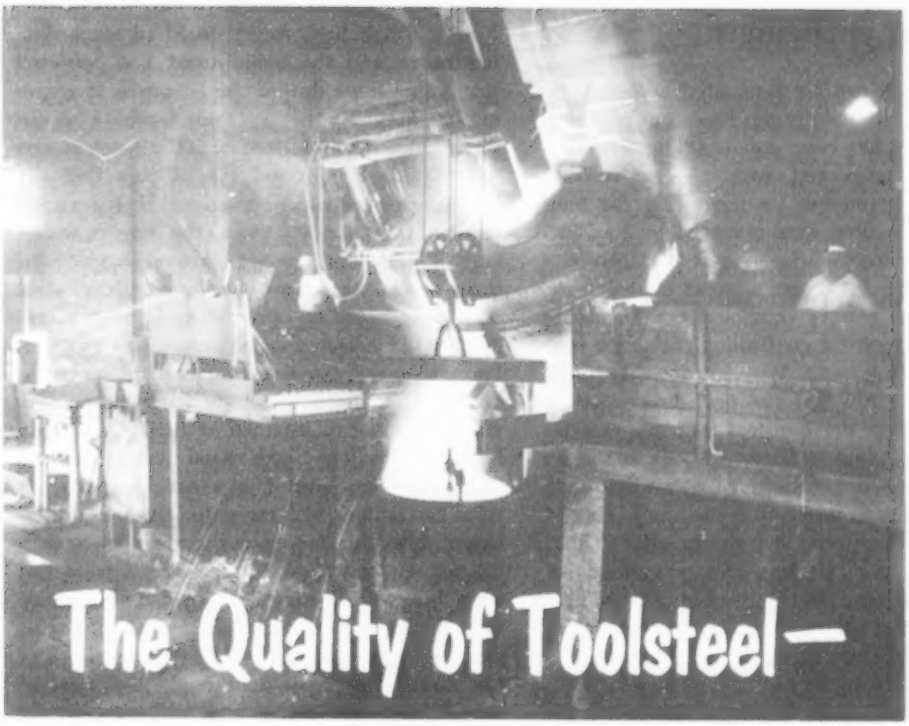


Fig. 4 – Calibration Curve for Inconel-Constantan Thermocouple for Temperatures to 160° F. Electrical resistivity of Inconel at 68° F. is 98.1 micro-ohms, specific resistance is 590 ohms per circular mil-ft.; resistivity of constantan at 68° F. is 49.3 micro-ohms, specific resistance is 294 ohms per circular mil-ft.

SUMMARY

Thermocouples of very small cross section can be successfully constructed to a design utilizing a hypodermic tubing and wire. The choice of the component materials is dependent on environment and availability of small diameter tubing. The central wire can be satisfactorily insulated from the tube by double and triple layers of spun glass impregnated with silicone resin. Satisfactory couples consisting of an insulated constantan wire enclosed in an Inconel tube were constructed and calibrated. These couples have a high thermo-electric power and hold their calibration well at temperatures up to 1110° F.



The Quality of Toolsteel—

Recent Developments and Future Predictions*

By BURNS GEORGE, Vice-President in Charge of Sales
Vanadium-Alloys Steel Co., Latrobe, Pa.

ONE OF THE MOST important factors in improving the quality of toolsteel has been the development of the electric melting furnace. With crucible melting, removal of impurities and control of chemistry were impossible. The advent of the electric furnace made close chemical specifications practical. In our own shop we actually allow our melter a two-point range of carbon for high speed steel and he hits it. Deoxidation is more thorough in the electric furnace and control of other gases is also possible to some degree. Because of the slag practices that may be followed refining is quite thorough. The presence of sulphur in the melt, for example, is of no concern whatever since very often it can be removed to a mere trace. Steels are much more uniform because larger quantities can be melted at one time and results can be duplicated from one heat to another.

Uniformity – The properties of plain carbon toolsteel have always varied widely not only from one manufacturer to another but from one heat to another in the same plant. Some heats of carbon toolsteel tend to harden to a greater depth than others, and some heats will develop a coarse grain upon slight overheating much more readily than others. A measure of these variations in the quality of carbon toolsteel is known as the "penetration fracture" or P.F. test, developed by Frank Shepherd of Ingersoll-Rand Co. With a good knowledge of electric melting

*Second portion of the annual McFarland Lecture presented before the Pennsylvania State Chapter ASM on May 8, 1953. The first installment was published in January.

practice, heats can be duplicated according to the P.F. test frequently ten times out of ten.

Uniformity has been enhanced by other developments connected with electric melting practice. A pyrometer for measuring the temperature of molten steel invented by Ray Fitterer, now dean of engineering at the University of Pittsburgh, has been a great contribution. Uniformity is further promoted by the use of the spectrograph for controlling chemistry during the melting cycle. With pardonable pride, I can inform you that the first direct-reading spectrometer in the toolsteel industry was installed at our plant in Latrobe about two years ago. It is the belief of melting experts that once toolsteel has been properly refined and brought to the point of tapping, it is detrimental to hold it in the furnace. Under ordinary methods of chemical analysis, holding was invariably necessary, but the use of the direct-reading spectrometer eliminates this problem, and reduces the time of melting by as much as an hour.

Segregation – Ingot molds of improved design are a natural outcome of electric melting. Along with control of time and temperature of melting, ingot mold design contributes to the control of segregation in highly alloyed steels. Big-end-up molds of short length, copper stools, heated hot tops, and the use of either chemicals or electrodes to maintain a pool of molten metal in the hot top and top of the ingot all have contributed to the reduction of segregation. There is probably as much difference between present-day steels and those of 1920 in respect to segregation as there is difference between a 1920 and 1953 automobile. That's saying a lot!

There can be no question but that excessive segregation is detrimental to the quality of toolsteel. It may lower cutting efficiency and may even cause cracks in hardening. Nevertheless, concern over the presence of a small amount of segregation has sometimes been overdone. It would be silly to think that a small amount of segregate in the center of a bar can be detrimental to the cutting efficiency of a tool whose cutting edge is at the surface of the bar. Yet, every young metallurgist will invariably pick segregation as the cause of a tool failure when 99 times out of 100 it had nothing to do with it. Each year, with each new crop of metallurgists, our people spend time refuting reports of this sort.

I remember once visiting an automobile plant where two or three hundred square tools made from a cobalt high speed steel had cracked in hardening and the metallurgist had reported that failure was due to the presence of segregation. Actually, the segregation which he observed at a magnification of 500 diameters was minor, and I informed the officials that the amount present was normal, and if it were the cause of failure, every tool in the country would crack. The plant manager turned purple and threatened to throw me out along with the steel until I requested an opportunity to make a fool of myself by heat treating some tools for him. Permission was granted and when we got to the heat treating department the first thing I saw was a lead pot maintained at 1050° F. Sudden heating of hardened high speed steel will always cause cracking and it was quickly apparent what had happened. I requested the heat treater to put through a few pieces in accordance with his regular practice. After removal from the quenching oil, he merely shoveled the pieces into that hot lead bath. The instant they hit the lead, they cracked. Fortunately for me, the metallurgist who had made the original report was a reasonable man and immediately reported to the manager that we had found the source of trouble and that it was not segregation. That metallurgist went on to become chief of his division.

Hot Work – Improvement in quality in the forging and rolling operations has been mainly an improvement in heating practice. Control of grain size is effected by accurate control of temperature; decarburization is controlled by furnace atmosphere. In the old days, most furnaces were coal-fired and were pretty crudely designed so that temperature varied considerably. If there was any control of decarburization it was simply by scaling the surface of the steel at a faster rate than decarburization could form. The heater was an able-bodied individual selected for his ability to shovel coal fast enough to maintain temperatures. He was usually able to keep a temperature of 2400° F. in one end of the furnace and 1900° F. in the other. Nowadays, that heater's stomach has sagged and his muscles have atrophied because all he has to do is switch a few valves on a gas-fired controlled-atmosphere type of furnace and watch a pyrometer to maintain accurate and uniform temperatures. The bars produced by a good mill nowadays are almost completely free of scale and have little if any decarburization. This means a great deal to the consumer who can purchase his bars much closer to size.

Good steel is not made in the inspection department. By that time it is too late. Neverthe-

less, inspection is a very important factor in the production of first-quality toolsteel.

The first thing to check is the hardness of the annealed steel for proper machining characteristics. This hardly needs comment here. The next step is inspection for seams, cracks, and other surface defects. In the old days, this was done by man preferably a bit on the stupid side, who looked over the surface of the bars and when he saw something suspicious he used a file to decide whether a seam or crack was present. Many were overlooked of course.

IMPROVING QUALITY BY INSPECTION

The Magnaflux system of inspection provides an almost perfect check for the presence of seams or surface cracks, and this process was used first in the toolsteel industry. In fact, the first royalty license was signed by Vanadium-Alloys Steel Co. When this inspection is applied to constructional alloy steels, the product is referred to as "aircraft quality" and you are charged extra. In the toolsteel industry we provide this service without charge as a further guarantee of quality.

Briefly, in the Magnaflux system the bars are magnetized with current of 900 to 5000 amp. in such a way that the only place a field of magnetism develops is at a crack or seam. The bars may be sprinkled with hydrogen-reduced iron or dipped in a liquid in which iron particles are suspended. These particles are attracted by the magnetic field at the location of the defect. In our practice we use dry iron powder coated with talc to make it more clearly visible.

This system cannot be used for drill rod or small-diameter wire, and at our plant we have developed a method of applying the Zyglo principle, likewise originated by the Magnaflux Corp. In this process the bars are dipped in a penetrating oil which contains a fine powder having fluorescent qualities. The oil is then washed off the surface of the bars but remains in any cracks or seams. When the bars are passed under ultraviolet light the fluorescent compound which has penetrated the defect is plainly visible.

The practice of cropping or fracturing the ends of bars for examination of grain size is probably a holdover from the old days when carbon content was judged by fracture rather than by chemical analysis. It is used now as a further check against overheating during manufacture and as a partial check for decarburization and internal defects such as pipe, flakes, and nonmetallic inclusions. It is a worthwhile inspection test. In our own practice both ends of every bar are examined in this way.

In addition to the fracture test, deep acid etching of disks from both ends of all bars except those of very small size is used to reveal center porosity and inclusions. Sometimes these disks are also heat treated and fractured to show the grain size of the hardened structure and to disclose nonmetallic inclusions.

There are several ways to inspect for decarburization. Ends of bars may be heat treated and the amount of decarburization measured by the depth of grinding necessary to reach full hardness. Or ends of bars may be machined with a specified depth of cut and the resulting chips analyzed for carbon content. A third method involves polishing a disk removed from the bar, etching carefully and measuring the depth of decarburization by microscopic examination. This latter method is favored by our laboratories. Microscopic examination of polished sections is also used to inspect high speed steel for segregation. This inspection is particularly important for steel that is to be used for thread chasers and other tools where the entire cross section of the bar becomes a cutting edge of the finished tool. Inspection of this type is tedious and time-consuming but insures the consumer that he is receiving the very best possible steel for his product.

While the inspection of disks from the ends of bars is a pretty fair guarantee against the presence of internal defects, it is not an absolute certainty – especially in large bars. Inspection of large bars throughout their entire length is now done by means of the supersonic Reflectoscope. This instrument can be adjusted to bounce a sound wave through bars of varying thickness. If a bar 6 in. square is to be examined the instrument is set to bounce the wave 6 in., and this is shown by an oscillograph attached to the machine. If the sound wave strikes an internal defect, it is reflected from this surface rather than from the opposite side of the bar, and this is also shown by the oscillograph. In this way the internal defect is not only detected, but its exact location inside the bar is also determined.

If all of these methods of inspection are pursued, one may assume that it takes almost as long to inspect a bar of toolsteel as it does to make it, and this is true. No toolsteel producer could stay in business very long if such rigorous inspection made it necessary to reject any great proportion of his product. He has to

follow careful manufacturing practices to avoid the defects disclosed by these various inspection procedures.

The question may then properly be asked, "Is all this inspection effort worth while?" From the consumer's viewpoint it is very much worth while. For example, a twist drill manufacturer might buy a ton of ⅝-in. diameter high speed steel wire for small drills. If, in the shipment, even just one or two 12-ft. lengths of wire are seamy, 50 to 100 defective drills would be produced and these would be mixed in with a large lot of drills. The manufacturer could not be sure whether all or only a few drills were defective and he would therefore be inclined to reject the entire lot. To him it is important that no defective steel be involved whatever. Likewise, a manufacturer might use a large piece of steel for a die-casting die and, when the die neared completion, find an internal defect of sufficient magnitude to mark the castings. It is not unusual for die-casting dies to cost as much as $50,000. It would be disastrous to find a defect when the die is just about completed, and here again it is the responsibility of the producer to supply material as near 100% perfect as possible.

BETTER COMPOSITIONS FOR BETTER PERFORMANCE

What is the effect of better quality on performance? I am sure many excellent tools were produced in the old days before steel reached its present state of perfection. However, there was a wide gap between the performance of the best and the poorest tools. Improving the quality of the steel has reduced this gap and made close duplication of performance possible. However, better performance is going to be obtained mainly through better quality imparted by the composition of toolsteels rather than by the elimination of defects or the manufacture of more uniform steels.

The future is going to see a much wider use of the high-carbon, high-vanadium types of high speed steel. I think they represent the greatest single advance in toolsteel metallurgy since the 18-4-1 type steel replaced Robert Mushet's self-hardening variety. The usefulness of these steels is limited only by the ability to grind. As better abrasives are developed the uses of these steels will expand. There is nothing to prevent going beyond the present high speed steels containing 1.50% carbon and 5% vanadium except the ability to grind them.

Other improved compositions I can predict for the future will be toolsteels having free-machining characteristics and precipitation hardening toolsteels. Die-casting dies, plastic molds, and dies for many other applications are very expensive to build because they require intricate machining and costly polishing operations after hardening. A boon to industry will be a die steel that can be heat treated to full hardness before any machine work is done. The danger of movement in hardening will thus be eliminated and the costly operation of polishing to remove the scale developed in hardening will also be eliminated. Some approach to this problem has already been taken. Our own firm is marketing a die steel which can be machined readily at hardnesses up to about 350 Brinell. Die steels which can be machined at still higher hardnesses are required.

Precipitation hardening steels are those which are given a preliminary heat treatment by the producer so that all the user needs to do after machining to develop full hardness is to temper at comparatively low temperatures – below the range for any serious scale formation. Hardness is developed in such steels by the precipitation of carbides held in solution by the initial treatment. A beginning has been made in this direction also. The ideal steel for solving the problems of machining and heat treating might entail a combination of free-machining and precipitation hardening characteristics.

In the category of manufacturing methods, I will predict improved rolling techniques for closer adherence to size tolerance. I will also predict that the higher-priced toolsteels will become available as hot rolled material completely free of scale and decarburization. Great strides have already been made in this direction. Such improvements in manufacturing could eliminate discard from the surface of bars by the toolmakers at great savings in cost.

This is a more important point than most of you realize. Do you know, for example, that the weight of a twist drill is just about one-third the weight of the piece of steel required to make it? The weight of a milling cutter is about 50% of the weight of steel required to make it.

Of course, with all the improvements we can invent we will still have the boys with secret heat treatments and secret powders who claim they can further improve upon the toolsteel producer's art. Perhaps they will bombard the steel with atomic rays or with ultra-high frequency sound waves to produce some mysterious quality which none of you metallurgists will be able to discover.

Critical Points

by the Editor

Welded Joints in Stainless Equipment

IT MAY BE NO news to say that metallurgists in producers' and consumers' plants now have enough experience with the stainless steels, plus reliable testing procedure to appraise the relative merit of new lots or analyses in specific environments, so that vessels and equipment do not corrode or eat away rapidly by general corrosion, all over the surface, unless the metal is ignorantly chosen or poorly heat treated, or unless the environment is radically changed.

No; failure is localized – most often at or alongside the welds. Apparently it would be easy to build and operate corrosion resistant equipment if it weren't for the joints. (A parallel statement was made at a recent meeting of the American Welding Society: "It would be easy to design, make and operate a pressure vessel if it weren't for the stress raisers.") Hence the importance of the study, started several years ago by the High Alloys Committee of the Welding Research Council, of welding techniques for Type 347 stainless steel (columbium-stabilized 18-10), and now being actively pushed by cooperative efforts of electrode manufacturers, steel producers, equipment builders, the chemical industry, and the U. S. Atomic Energy Commission.

Many names for many weld defects have appeared in the literature – so many, in fact, that it is likely that one single thing or cause may have acquired several names. Hence the wisdom of the Committee's preliminary survey of industrial experience wherein the power and chemical industries were thoroughly canvassed, and a record made of the matters which have actually given trouble either in fabrication or use of heavy plate. Cracks within or alongside the weld, either as it is made or possibly developing at a later date, turned out to be the bothersome things, and the whole matter has been generalized by saying that such defective joints have "crack sensitivity". Hence, a prime requirement is that the welds – either as made in the fabrication shop, by the erector, or subsequently by the repair man – have an absolute minimum of "crack sensitivity". To define this trait, accurately and inclusively, is no easy thing to do, as you may well imagine.

Six types of arc welding electrodes for Type 347 stainless are now under study. Among them is one, widely used, which produces austenitic weld metal containing 5% ferrite, more or less. Apparently this ferrite reduces crack sensitivity or fissures, and so would be desirable were it not for the fact that it tends to transform into brittle sigma phase if the equipment operates at more than very moderate temperature. Rod compositions, high in nickel, are available which form fully austenitic welds, but these in turn are more crack sensitive in their very early history. Nevertheless, European engineers, wanting to build steam power plants to operate higher than the present maximum of 1110° F. have been asking for single-phase welds.

The electrode problem is not as simple as it sounds. The electrode itself is a composite of core rod or wire and coating. The two must be so formulated and adjusted that the final weld metal is sound, free from elements or compounds in unstable solution; the weld, also, is usually different in composition from either the core rod or the metal being joined. The problem is further aggravated by the fact that welding operators have variable techniques or procedures, so the final weld metal cannot be precisely predicted from the electrode.

The Committee's program and its personnel are such as to inspire confidence in its success. Meanwhile it should be emphasized that it is the poorest of all possible economy to buy fabricated stainless equipment on price alone. Sound metal, properly chosen, correctly joined and adequately heat treated, is essential to avoid expensive and quick failures. It costs money. It is worth what it costs.

Launching of the Nautilus

ON MAY 17, 1897, a little ship called the Holland after its inventor was launched from Lewis Nixon's shipyard at Elizabethport, N. J. The *New York Times'* report said:

"Few boats built in recent years have attracted so much attention among naval officers. If the Holland proves a success, she might render the great floating forts of the nations useless, for she has the most powerful of all means of destruction, the torpedo, combined with the most effective of all armors, being invisible and

traveling, when in action, beneath the water."

On Jan. 21, 1954, a little ship called the Nautilus (S-571) was launched from the shipyard of Electric Boat Division of General Dynamics Corp. at Groton, Conn. On this occasion Admiral Robert E. Carney, Chief of U. S. Naval Operations, said:

"As a sailor, I recognize this ship as the beginning of a new chapter in the history of sea power, and I see new vistas of American sea power unfold. As remarkable as it seems to us now, it will probably appear to our sons as a quaint old piece of machinery. This is sure to happen, for this is only the beginning. As an American, I feel an intense pride in the teamwork that went into the Nautilus. As one small human being, a very grave speculation as to what this event may signify in terms of the things in store for humanity is partly offset by the hope that springs eternal. The Nautilus is symbolic of man's dreaming, his out-reaching imagination, his continuing genius, his search for truth. The Nautilus is a symbol of the United States' determination to fight, when and if fighting becomes necessary, for the preservation of the principles for which we stand."

The morning had been so damp and foggy that the Nautilus's propellers, 300 ft. away, were dim in the mist. As the chaplain prayed God that peace would bless our country, and Mrs. Eisenhower broke the bottle on Nautilus's slow-moving prow, a brisk breeze suddenly swept the Thames, the sun broke through, and the ship moved from twilight into glorious day.

May it be a symbol of her future!

ADDENDUM ON THE SUBMARINE

Again quoting from the old issue of the *New York Times:* "The Holland is something in the shape of a cigar. She is 50 ft. 3 in. long. The diameter at the greatest circumference is 10 ft. 3 in. She is calculated to travel 8 knots under water and 10 knots on the surface. Her submarine radius is 64 miles. Power is furnished by a gasoline engine while traveling on the surface, and by a dynamo when submerged.

"The full service crew of the Holland will consist of six men. Sleeping and living quarters there are none. Not being built for long trips, the boat needs no such quarters. There is no armor protection, the sheathing of the boat being of the kind used by the Government for the hulls of warships."

As to the Nautilus, official data are almost entirely lacking – for example, in the semi-annual report of the U. S. Atomic Energy Commission. A scheduled briefing for "science writers" was suddenly cancelled. From scattered articles (nonofficial) in the engineering press and from press data issued at the launching, the following may be gleaned:

Design of the prototype reactor (Mark I) was started at Argonne National Laboratory of the U. S. Atomic Energy Commission in 1948, and a development and construction contract given to Westinghouse Electric Corp. in December of that year. The power plant was installed in a section of a submarine hull at Arco, Idaho, as a joint project of Westinghouse, A.E.C., the U. S. Navy, and Electric Boat. It operated at full power in June, 1953. It is said (nonofficially) that the fuel is natural uranium enriched with the fissionable isotope U^{235}; this metal is protected from corrosion by zirconium; the moderator – material which slows the neutrons down to effective thermal speeds – is superheated water (temperature and pressure unknown). Reflectors and shielding have not been specified. The hot water moderator is also the coolant – that is, it circulates from the reactor core to a heat exchanger; steam is generated in the latter to drive steam turbines geared to the propeller shafts and to electric generators for other services.

Since this power plant requires no oxygen and generates no flue gases, the Nautilus "could cross the Atlantic submerged at full speed – in excess of 20 knots – without surfacing" (to quote a press release). This fact is the unique characteristic of the Nautilus; ordinary submarines must surface at frequent intervals. No information is given as to the horsepower generated, but since the ship is fatter and faster than a fleet submarine, it is certainly more than the 6000 hp. of the old types – maybe double.

Keel of the Nautilus was laid June 14, 1952. It was about 80% complete at launching and displaced about 3000 tons. Its shakedown cruises are planned for early summer. Its reactor and power plant, Mark II, was built (doubtless with modifications suggested by experience at Arco) by Westinghouse Electric Co. at Bettis Field, near Pittsburgh. The cost of a fleet-type submarine is said to be about $15 million. The Nautilus will cost about $29 million *plus* cost of the Mark II power plant (undisclosed). It is estimated that the second submarine of the Nautilus class, minus reactor, would cost in the neighborhood of $20 million.

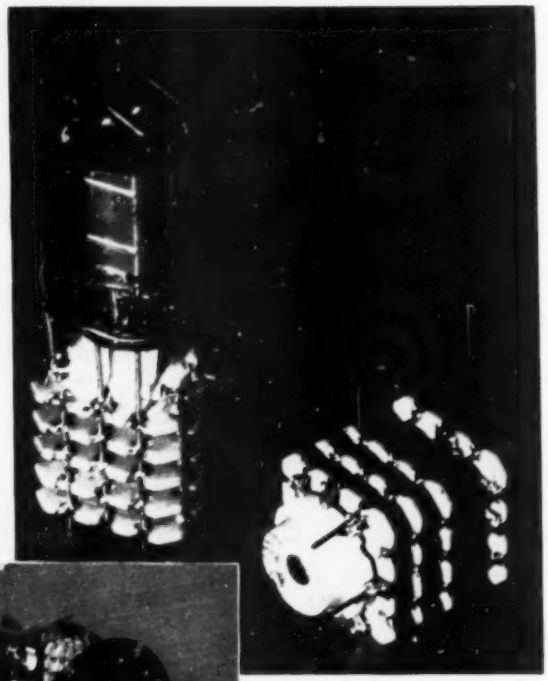
Project Tinkertoy

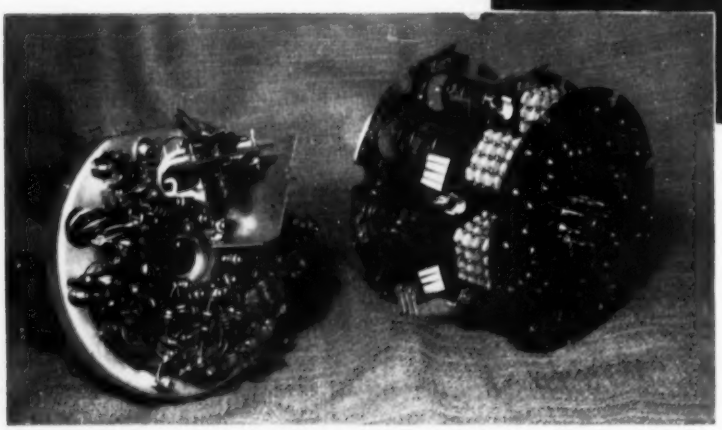
Mechanized Manufacture, Inspection and Assembly

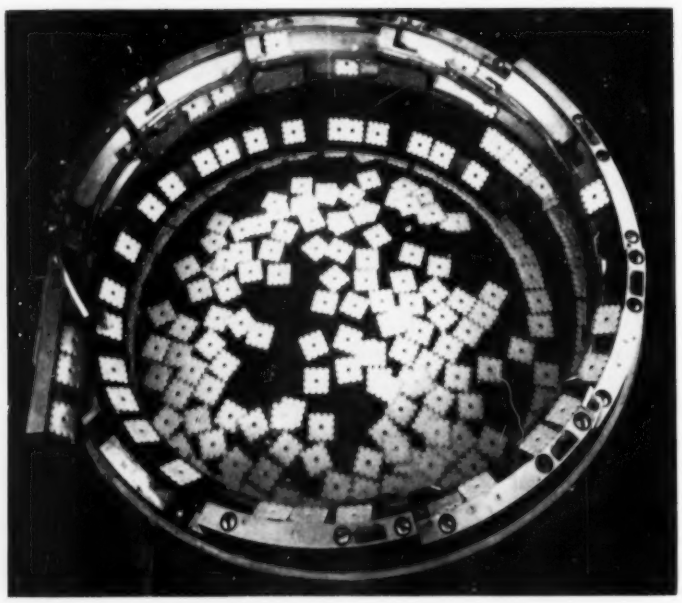
PROJECT TINKERTOY, the highly mechanized method of manufacture and assembly of radio gear evolved by the National Bureau of Standards, eliminates all the hand work formerly needed to join various electrical components. This saving in manual work results from the use of modules or primary units for each electron tube stage. In turn, the module is made up of several ceramic wafers, each of which bears a portion of the complete circuit. These pages show some of the operations performed by the highly special – and expensive – machinery in a pilot plant in Arlington, Va.

Conceived in necessity, the project had the backing of the Navy's Bureau of Aeronautics, which had sometimes been forced to use aircraft without their important electronic instruments – largely because aircraft were being produced faster than the instruments. This condition will be corrected with the new system of manufacture and assembly that cuts the lead time for new electronic equipment by about 75%. The present plant, using 15,000 sq. ft. of floor space and only 35 workers, can make 1000 modules per hr. for sonobuoys – but the system can be converted to the production of other subassemblies in a matter of minutes.

The MDE (modular design of electronics) module is a primary unit, dimensionally standardized but having a wide range of electrical functions. As shown at right, each module is an assembly of four to six ceramic wafers bearing printed conducting circuits, tape resistors, capacitors and tube sockets, all of which are made, inspected and assembled in a mechanical system called MPE (mechanical production of electronics). The view below shows electronic equipment produced by conventional hand methods of conventional component parts (left) and an MDE module.

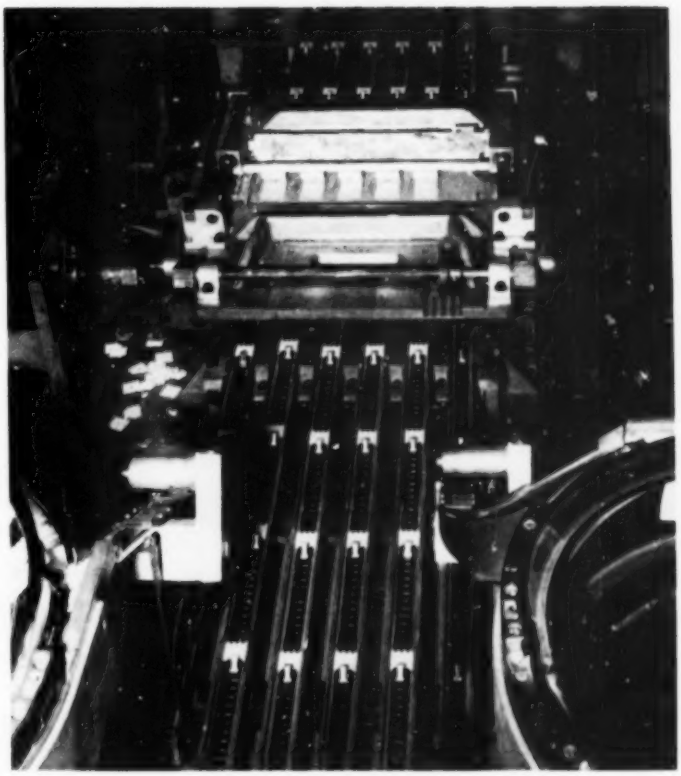


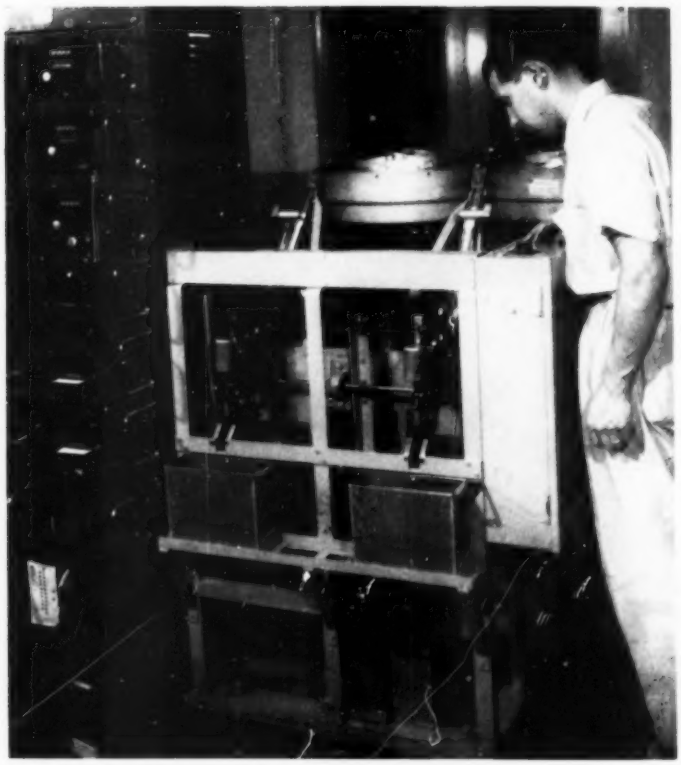




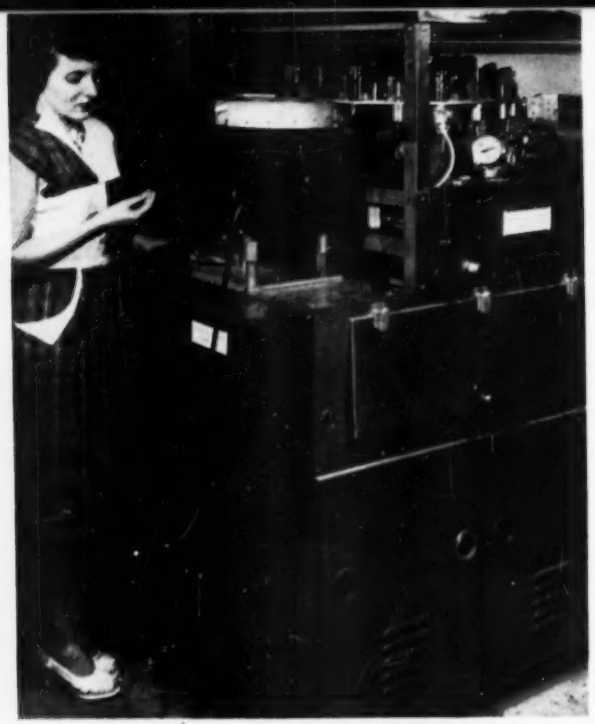
A vibratory bowl feeder is used to issue oriented wafers and component-mounted wafers during the MPE operations. Each ceramic wafer (1/16 in. thick, ⅞ in. square) has 12 notches for the connecting wires and a keying notch on one of the edges that orients the wafer. The spiral channels have stops at the exit which pass the wafer only if the keying notch is in the proper position to match the stop. Steps and inverting grooves are placed in the channels to turn and invert the wafer until the key-notch falls in the proper position.

As MPE wafers issue from vibratory feeders (foreground), they pass under a stencil screen for printing circuit patterns on wafers. The patterns are printed simultaneously in silver for the conducting circuit, and dried in an oven, after which the wafers are inverted and conveyed to another stencil screen where the unprinted surfaces are given appropriate circuit patterns. The patterns are later bonded to the ceramic surfaces in a curing furnace.



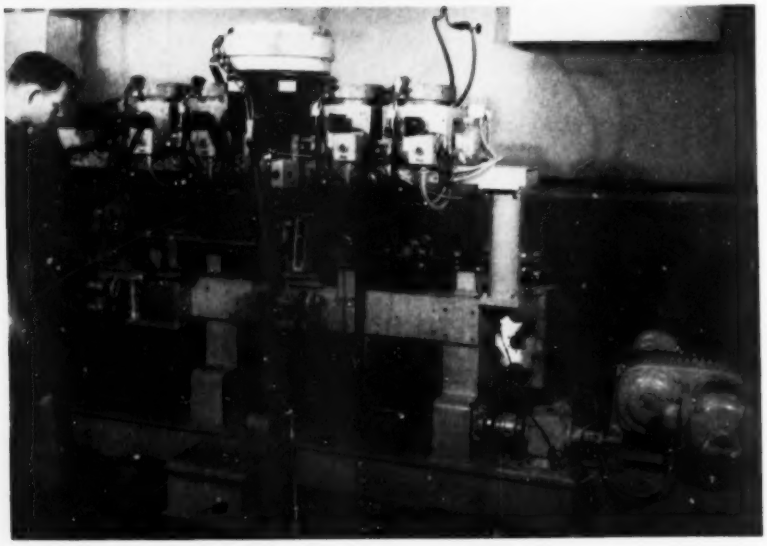


In MPE inspection of pattern-printed wafers the appropriate inspection circuit is regulated by a program punched on a card which accompanies the particular batch of wafers from its initial printing up to its final assembly into a module. Wafers from the curing furnace are loaded into a vibratory feeder (to the right of the operator) from which they issue oriented and faced. All of the wafers pass under an inspecting device which automatically checks and accepts those bearing the proper conducting circuits.



Surface tinning of MPE component parts is automatic. Here a machine deposits a thin coating of solder on the silvered portions of the capacitors. (A similar machine performs the same function on the wafers.) The bodies issue from a vibratory feeder into clamping jaws, are dipped into a flux vat, then a solder bath, and finally a wash. Only the silver overlays retain the solder.

In the center photograph an MPE capacitor-wafer assembling machine is bonding one or two condensers at a time to each wafer surface. Capacitors come from the smaller vibratory feeders on top of the machine. Electrically operated escape mechanisms reject improperly oriented capacitors. The first two capacitors are centered in the assembly jig by a slave, and the properly oriented wafer then falls on top of the jig, followed by the remaining two capacitors. The jig, which is wound with the secondary windings of an induction heater, is conveyed through a high-frequency coil and the tinned surfaces are bonded together.



After the wafers, each with proper attachments, have been assembled into a module, riser wires are trimmed to length and the unit is automatically inspected in this machine. A punched card programs the computer circuits, and the electronic system inspects each circuit or component part mounted on the wafers and compares it with a standard circuit or part.

Protection of Hot Work Tools in Heat Treatment

THE SERVICE LIFE of a hot work tool may be seriously impaired by either carburization or decarburization produced on the surface during heat treatment. Unless generous grinding can be done after heat treatment, it is extremely difficult to produce hot work tools which have neither carburized nor decarburized surfaces.

The protective atmospheres in certain types of furnaces and in molten baths should, theoretically, be inert. Practically, however, they are often carburizing. This is because the atmospheres are adjusted for high-carbon toolsteels (1% C, or higher), while most hot work steels are in a range of 0.35 to 0.60% carbon. Even protective packing materials such as cast iron chips, wood charcoal, or spent carburizers, which are relatively inert to high-carbon toolsteels, will carburize hot work steels. On the other hand, noncarbonaceous materials such as mica or sand are decarburizing. The situation is thus one where a desirable objective is recognized but cannot be attained in most production heat treatment equipment.

Protective flux coatings such as borax, borax water glass, and silica water glass have been used to avoid decarburization from oxidizing atmospheres. However, these coatings are difficult to remove from the tools and investigation has shown that they do not protect against decarburization but merely slow down rate of decarburization.

The most commonly used protective metallic coating is copper plating for a "stop-off" in carburizing. Tests made with production equipment have shown that copper plating approximately 0.001 in. thick, which is commonly used, is not fully effective, but if it is built up to thicknesses of 0.003 to 0.006 in. or more, it protects the underlying steel from a carburizing atmosphere. However, such copper plate does not protect steel against decarburization in an oxidizing atmosphere because the copper oxidizes rapidly at elevated temperatures. Nevertheless, since a proper copper plate is effective in preventing carburization it should be possible to heat treat hot work tools by copper plating them and then heating them under *carburizing* conditions which will protect the copper plate.

A series of tests was made to determine whether a widely used Cr-Mo-W type of hot work steel (S.A.E. type H 12) could be protected in this way. Its complete analysis was 0.33% carbon, 0.38% manganese, 0.86% silicon, 5.03% chromium, 1.45% molybdenum and 1.50% tungsten. Fourteen test bars 1 in. in diameter by 5 in. long were prepared by grinding from 1¼-in. diameter bar stock. Four test bars were copper plated to a depth of 0.003 in., five to a depth of 0.006 in.; the remaining five bars were bare.

The test bars were heat treated in an electric resistor furnace having an ordinary air atmosphere by the following cycle:

Preheat at 1300° F. for 1 hr.
Transfer to furnace operating at 1850° F.
Hold at 1850° F. for 1 hr.; oil quench.
Temper at 1200° F. for 2 hr.; air cool.

Some of the test bars were protected by packing them in carburizing agents of widely varying activity, including cast iron chips, wood charcoal, and a commercial carburizing compound. In order to determine the amount of decarburization or carburization resulting from the various packing materials, and to determine the effectiveness of the protection of copper plating, chips machined in increments of 0.005 in. to a depth of 0.025 in. from the surface were analyzed for carbon. Table I shows the results for each set of conditions.

Two specimens were held for 10 hr. at 1850° F. instead of 1 hr., to determine the effectiveness of copper plating for longer periods of time.

The following observations can be made on the basis of the carbon analyses:

Bar No. 2 – Heavy decarburization of this bar indicates that the air atmosphere in the furnace was strongly oxidizing, as would be expected from the test conditions.

Bar No. 3 – A copper coating 0.006 in. thick

By J. Y. RIEDEL, Toolsteel Engineer
Bethlehem Steel Co.

Fig. 1 – Three Copper Plated Test Bars After 1 Hr. at 1850° F. Left: Bar No. 6, packed in cast iron chips. Center: Bar No. 12, packed in commercial carburizer. Right: Bar No. 9, packed in wood charcoal

does not furnish appreciable protection in such an oxidizing atmosphere.

Bar No. 4 – Cast iron chips are mildly carburizing to this 0.33% carbon hot work steel. The extent of carburization obtained on this sample may not be sufficient to harm the service of many types of tools; however, since the quality of cast iron chips is not under control, the reproducibility of these results is not certain.

Bars No. 5 and 6 – Copper coatings either 0.003 or 0.006 in. thick protect the hot work steel perfectly from carbon coming from a mild carburizer such as cast iron chips.

Bar No. 7 – Wood charcoal is a moderately active carburizer on this hot work steel.

Bars No. 8 and 9 – Copper coatings either 0.003 or 0.006 in. thick provide excellent protection of the hot work steel from carburization by a moderately active carburizer such as wood charcoal.

Bar No. 10 – A commercial carburizing compound produces a fully carburized case on this hot work steel, as would be expected.

Bars No. 11 and 12 – Copper coatings either 0.003 or 0.006 in. thick provide excellent protection from an active commercial carburizer.

Bars No. 13 and 14 – The above statement also holds for exposures of 10 hr.

It is noted that test bars No. 8, 9, 11, 12, 13 and 14 are all slightly carburized even though copper plated. The amount of carbon picked up is considered negligible, since the actual carbon content of the outermost 0.005-in. layer is within the range of carbon normally existing in this type of steel. No evidence of extra carbon could be found microscopically.

Removal of the copper plated coatings from the test specimens after heat treatment was expected to be troublesome, but they actually peeled off very easily. This is shown in Fig. 1. During heat treatment the copper separates completely from the steel and buckles slightly, so that the coating can be stripped like bark

Table 1–Carbon Analysis of Turnings From Test Bars

Bar No.	Protection	Copper Plate Coating	Time at 1850° F.	Location of Sample					
				0 to 0.005 In.	0.005 to 0.010 In.	0.010 to 0.015 In.	0.015 to 0.020 In.	0.020 to 0.025 In.	Mid-Radius
1	Untreated control bar	None	None	0.35%	0.34%	0.33%	0.33%	0.33%	0.33%
2	None	None	1 hr.	0.05	0.10	0.11	0.14	0.19	0.33
3	None	0.006 in.	1 hr.	0.11	0.18	0.24	0.28	0.30	0.34
4	Cast iron chips	None	1 hr.	0.42	0.41	0.41	0.39	0.40	0.33
5	Cast iron chips	0.003 in.	1 hr.	0.34	0.34	0.34	0.34	0.34	0.33
6	Cast iron chips	0.006 in.	1 hr.	0.34	0.33	0.34	0.34	0.34	0.33
7	Wood charcoal	None	1 hr.	0.90	0.95	0.90	0.86	0.81	0.33
8	Wood charcoal	0.003 in.	1 hr.	0.37	0.36	0.37	0.35	0.35	0.33
9	Wood charcoal	0.006 in.	1 hr.	0.38	0.37	0.37	0.36	0.36	0.33
10	Carburizing compound	None	1 hr.	1.62	1.49	1.38	1.26	1.10	0.33
11	Carburizing compound	0.003 in.	1 hr.	0.38	0.37	0.35	0.35	0.35	0.33
12	Carburizing compound	0.006 in.	1 hr.	0.39	0.39	0.39	0.38	0.36	0.33
13	Carburizing compound	0.003 in.	10 hr.	0.39	0.39	0.39	0.39	0.39	0.33
14	Carburizing compound	0.006 in.	10 hr.	0.40	0.40	0.39	0.39	0.39	0.33

from a log. The surface of the steel after removal of the copper has a dark temper color which can easily be removed by wire brushing, if desired. In many applications, a temper colored surface is advantageous in improving the lubrication during operation.

Summary and Conclusions – Hot work toolsteels can be hardened in furnaces which do not have controlled atmospheres by copper plating the tools and then protecting the copper plate during heating by packing them in a material which has a carburizing potential. Later the copper plating can be readily stripped from the steel, leaving a smooth surface which shows a dark temper color. Tools which have been treated in this manner do not require grinding after hardening because both carburization and decarburization of the surfaces are avoided.

Caution – Do not use copper plating on hot work toolsteels which must be heated above 1950° F. for hardening. In an excessively high temperature the copper will melt and damage tool surfaces by alloying with the steel.

Book Review

Role of History in Evaluating Materials

By JOHN R. TOWNSEND*

HISTORY OF STRENGTH OF MATERIALS, by Stephen P. Timoshenko. 452 p., McGraw-Hill Book Co., New York. $10.00

History may concern itself with several possible themes. It may be rigid chronological recitation of facts, the story of development of a civilization, or it may concern itself with the challenge that nature presents to a people. In a broad sense, the history of engineering is a story of how man has overcome the challenge of nature. As we reach maturity we become more interested in how other men solved the problems that came within their experience.

It is quite logical, therefore, that Stephen Timoshenko should have given to students in engineering mechanics who have already had knowledge of strength of materials and theory of structures, a course in the history of strength of materials. He has given this course for 25 years and the present book covers this ground in a most exhaustive way; because of his mastery of several languages, he is familiar with the literature of the world on this subject.

The approach is along the line of basic or fundamental relationships and the ability of these relationships to explain the phenomena of materials testing. To a certain extent he shows the influence of the developments in other fields but does not philosophize on the effect of development of elastic theory on engineering progress. The postulation of a homogeneous and isotropic material is an important convention in the solution of relationships that can be expressed in the rigorous language of mathematics. Such a material is an oversimplification since we are required to use nonhomogeneous materials.

The allied fields of metallography, molecular structure, and solid state physics must be comprehended for a full understanding of the phenomena of materials. He shows the influence of fatigue, corrosion fatigue, single crystal deformation phenomena and inhomogeneity. However, engineering has thrust itself into new environments and these will require exhaustive experiments before basic theory can be well established, as will be seen later.

This leads to the interesting relationship between the availability of fundamental knowledge and engineering progress. Timoshenko's excellent book gives us the opportunity to indulge in such a speculation:

The Parthenon was built in 447 B.C. At this time there was no formal knowledge of the strength of materials. Archimedes discussed the lever and the center of gravity but this was more than 200 years later. It was not until Galileo about 1600 A.D. described the properties of a beam that man had any knowledge of structures, yet the Colosseum in Rome had been built very early in the Christian era, and the

*Mr. Townsend is director of material and standards engineering, Sandia Corp. He is a past president, American Society for Testing Materials, and was formerly supervisor of metallic materials, Telephone Apparatus Division, Bell Telephone Laboratories.

Book Review

Basilica of St. Peter was dedicated during Galileo's lifetime. These tremendous structures exist today and take full advantage of the columns, trusses, arches and abutments – designed and built by rule of thumb rather than by mathematical formula.

So much for large structures. How about machines?

Robert Hook (1635-1703) did the first experimental work on the elastic properties of metals and established the fundamental laws we recognize today. Mariotte (1620-1684) made the first tension tests, and Bernoulli (1700-1792) extended Galileo's work on beams to a more logical theory. Euler (1707-1783) demonstrated the lateral vibration of bars and the properties of columns. It is a singular thing to remember that only a few years later, in 1793, Eli Whitney invented the cotton gin and in 1800 had demonstrated interchangeable manufacture for the first time.

During the 17th century and the beginning of the 18th metallic materials were investigated by scientific methods by men working in the academies. For example, Lagrange (1736-1813) columns, Parent (1666-1716) beams, Coulomb (1736-1806) tension tests, arches, strength of materials, and friction. Girard in 1798 published the first book on materials. In France the first engineering school was established in 1795, namely Ecole Polytechnique. For years this school was the focal point for the development of the mathematical theory of elasticity. Monge, Navier, Poisson and Lamé were outstanding in this era.

Columns and Beams of Sandstone, Erected at Stonehenge About 4000 Years Ago

Then came a rush of invention and discovery. The first railroad engine was invented in 1801, the first steamboat in 1802, the Jacquard loom in 1804, electroplating in 1805, the Otto engine in 1823, the first turbine in 1829, the Morse telegraph in 1837, vulcanization of rubber in 1839, smokeless powder in 1846, openhearth steel in 1867, the first Atlantic cable in the same year, electric steel in 1870, bessemer steel in 1877, and gasoline in the same year. During this period of discovery and invention there was little work except theoretical speculation on the properties of materials. In Great Britain, Fairburn (1787-1874) made tests on boilers and ship plates and Hodgkinson (1789-1861) made compression tests on a variety of materials. In Germany, Weisbach (1806-1871) made the first tests on materials in which students participated.

Malleable iron came into use in bridge construction in 1840 and in 1843 Rankine published his first paper on fatigue of railroad axles. Wöhler (1860-1914) published papers on the fatigue of iron and steel. By this time experimental engineering was well established.

Then there was a short pause. It was not until around the beginning of the 20th century that there occurred a rush of new developments that were to transform the world–the automobile in 1885, the first bicycle a year later, the first diesel engine in 1892, high speed steel in 1900, Manley's rotary engine in 1902 and the first airplane in 1903.

The next great period of industrial development started during the first World War and ensuing years. Brearley's stainless steel was first made in 1912. This period was really dominated by great discoveries in the chemical industry, such as neoprene, butadiene and water resistant glues, all in 1932. During this period for the first time, the engineering world (in contradistinction to the scientific investigators) came to realize materials were no longer homogeneous. Publication of Rosenhain's "An Introduction to the Study of Physical Metallurgy" in 1914 and Jeffries and Archer's "Science of Metals" in 1924, and a number of

(Continued on p. 178)

By R. W. HANZEL
Associate Metallurgist
Applied Metallurgy
Armour Research Foundation
Chicago

Surface Hardening Processes for Titanium and Its Alloys

FOR THE PAST several years, the Armour Research Foundation has been engaged in research on processes for the surface hardening of titanium and its alloys. This research anticipated the inevitable wider usage of titanium. Although the elements presently used for surface hardening are regarded more as contaminants in the currently available materials, this work foresees the same elements, under technical control, being used to achieve the required surface hardening.

At the outset of the program, it was obvious that there would be many possible methods for accomplishing the surface hardening of titanium. Since it is generally true that one or only a few of these possible processes will offer advantages that are not inherent in the others, the initial investigation was devoted to a general survey of the entire field of possibilities involving the metalloid elements.

Recognition of the possible sources of surface hardening produced by the addition of an element to a metal or alloy was necessary in planning a systematic research program. Understanding the fundamentals of these processes served to guide the program along the most fruitful path. From this work, it was possible to select the most likely treatments that would give the desired results. The various sources of hardening that have been considered include the following:

1. Formation of a hard compound on the surface; for example, anodized aluminum.
2. Production of a diffusion layer that can be hardened by subsequent heat treatment; for example, carburization of steel.
3. Solid solution hardening effect; for example, the solid solution of oxygen or nitrogen in alpha titanium.
4. Precipitation hardening effect; for example, internal oxidation of a solute component, or nitrided steel.

SOLID SOLUTION HARDENING

The surface hardening and transformation characteristics of titanium and its alloys differ considerably from those of steel, and therefore the commercial surface hardening treatments for steel cannot be applied directly to titanium. The likelihood of treatments being developed around 1, 2 or 4, above, do not appear favorable. Hard surfaces produced by chemical treatment would undoubtedly be too thin for many of the applications involving high load concentrations and wear, although corrosion resistance at elevated temperatures may be enhanced. As for precipitation hardening, it is questionable whether alloying elements can be found that will form sufficiently stable com-

pounds in titanium-base alloys to realize such a dispersion. An addition agent must preferentially react with the alloying element in the presence of titanium.

Of the four hardening mechanisms, the solid solution hardening effect appears to possess the greatest potential. Surfaces of extreme hardness can be developed in titanium and polycomponent alloys involving the metalloid elements oxygen, nitrogen, carbon and boron.

The solid solution hardening of titanium by the metalloid elements is rather well known.* Apparently, the greatest effect is caused by nitrogen, which gives extreme hardening but in large amounts seriously embrittles the diffusion layer. Oxygen has a less drastic hardening effect; high oxygen contents in the surface and subsurface layers result in the formation of a loosely adherent scale. Carbon does not embrittle the titanium to as large an extent as oxygen or nitrogen, nor does it harden to the same depth (undoubtedly because of the limited solid solubility of carbon in alpha titanium). Hydrogen appears to increase the surface hardness slightly, but results in serious embrittlement. The addition of boron leads to unusually high hardnesses; however, the usefulness of the product is doubtful.

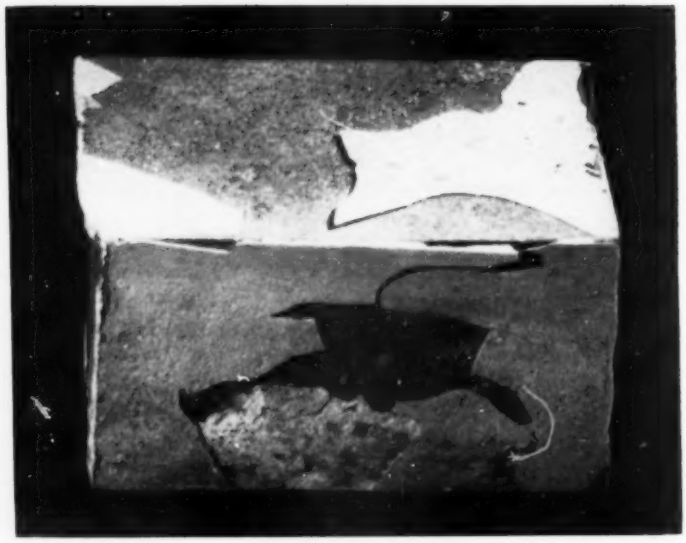


Fig. 1 – Scaled Condition of Titanium After Being Heated in Air for 16 Hr. at 1800° F.

SAMPLE PREPARATION AND EVALUATION

Samples used in all phases of this study were prepared as uniformly as possible in order to reduce to a minimum the variables introduced by nonuniform surface conditions and to facilitate surface hardness testing. The procedure was, first, to grind the samples to obtain parallel surfaces, and second, finish the resulting surface through the four-zero paper. All samples were examined for hardness increase, weight change, dimensional stability, and microstructure.

A Tukon microhardness machine was used in the tests for surface hardening and for measuring the hardness gradient on microsections prepared normal to the specimen surface. A Vickers 136° diamond, 100-g. load, and 4-mm. objective were used. Test conditions remained uniform except for minor variations caused by peculiarities of a few individual treatments.

Hardening by Oxygen – The controlled addition of oxygen to titanium or its alloys does not appear commercially feasible at this time. The work at Armour Research Foundation involved the heating of titanium in air with and without dehydration. Results indicated that little hardening occurs from heating for as long as 6 hr. below the transformation temperature, but all higher tempertures produced a noticeable gradient in 1 hr. In general, higher temperatures and longer times in the beta range gave higher surface hardness and deeper penetration.

The surface hardening produced by heating in air is almost always accompanied by serious embrittlement. At the higher temperatures where appreciable hardening results, a considerable amount of scale is formed. This scale spalls and roughens the surface as shown in Fig. 1. Treatment in dry air appears to reduce this undesirable scaling to some extent. Slight increases in surface hardness and depth of penetration are also evident.

Water quenching of samples heat treated in

*The basic work on this mechanism is described in two early references: "Effects of Three Interstitial Solutes (N_2, O_2 and C) on the Mechanical Properties of High-Purity Alpha Titanium", by W. L. Finlay and S. A. Snyder, *Transactions*, American Institute of Mining and Metallurgical Engineers, Vol. 188, 1950, p. 277 and 1368; "The Effect of O_2, N_2 and H_2 on Iodide-Refined Titanium", by R. I. Jaffee and I. E. Campbell, *Transactions*, American Institute of Mining and Metallurgical Engineers, Vol. 185, 1949, p. 646 to 654.

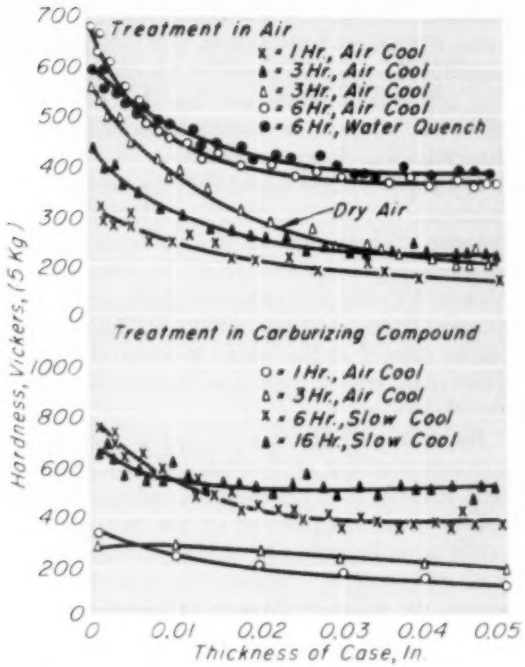


Fig. 2 – Hardness Gradients Produced in Unalloyed Titanium (Ti-75A) by Treatments in Air and Carburizing Compound (Houghton Pearlite 120) at 1800° F. Original hardness of specimen, ¾-in. round, was Vickers 180. All hardnesses are for 5-kg. load, except for samples carburized 6 and 16 hr. which are for 100-g. load

air is not beneficial to surface hardness. The surface hardness of water quenched samples of titanium and its alloys generally is appreciably lower than of similar samples that are air cooled. This is thought to be due to the development of micro quench cracks on the surface. Although a martensitic type of structure is produced with the quenching from the beta range, no appreciable hardening accompanies this transformation. In view of this, there is little to be gained by quenching in water.

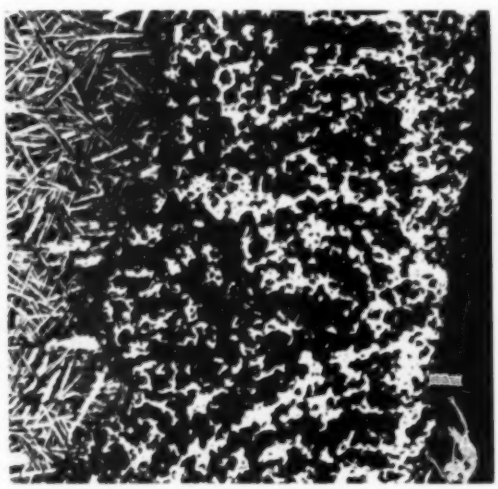
Hardnesses resulting from treatments at 1800° F. for various times are plotted in Fig. 2.

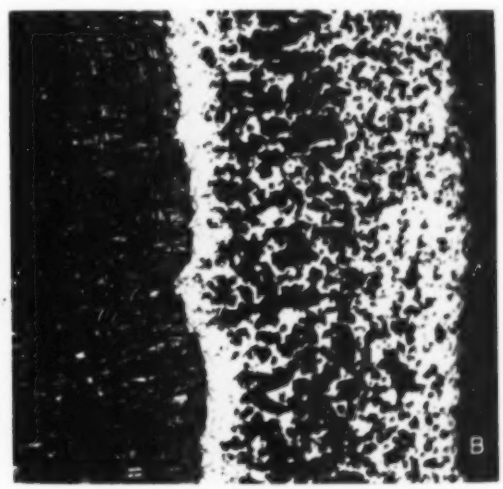
Laboratory experiments using reduced pressures of oxygen (10^{-3} and 10^{-2} mm. Hg) have been reported by H. W. Worner ("Surface Hardening of Titanium", *Australasian Engineer*, November 1950, p. 52-55). Results appear to be similar to those obtained with purified nitrogen gas; however, process controls appear extremely critical for use on a commercial scale.

Hardening by Carbon – Gas and pack carburizing of titanium produces surface layers that are rough, porous and loosely adherent.

Figure 2 also shows the high hardnesses of surfaces which had been pack carburized at 1800° F. for various lengths of time. Penetration is deep, but the material is badly embrittled, this brittleness becoming greater as the time and temperature of treatment are increased. At the higher temperatures, brittleness was evident throughout a ⅜-in. round sample. These results indicate that pack carburizing is not particularly useful. Although there is some doubt about the actual mechanism of pack carburizing, the titanium probably absorbs more oxygen and nitrogen than carbon. Hence, results are similar to treatments in air.

Fig. 3 – (A) Treated for 1 Hr. With Propane Gas at 2000° F. (B) Treated for ½ hr. with propane gas followed by ½ hr. holding at 2000° F. for diffusion. Thickness of white layer beneath porous case is 0.0004 in. 250×





Hydrogen Treatments Impractical

With a view toward eliminating the particularly undesirable effect of oxygen and nitrogen during carburizing, a limited experimental survey was undertaken to determine the effect of carburizing in a propane atmosphere. In general, the treated specimens showed a decided tendency to flake and spall and had a heavy porous layer. Figures 3A and 3B illustrate carburized cases which are typical for treatment with propane gas. In several instances, a thin carbide layer was visible immediately beneath the porous case as shown in Fig. 3B. It was believed that dilution of the propane would reduce its "sooting" tendency, and build up the hard carbide layer and thereby eliminate the porous layer.

More recent work (reported at the 1953 Spring Meeting in the paper "Surface Hardening of Titanium by Carburizing and Induction Heat Treatment", by A. J. Griest, P. E. Moorhead and others) involving dilute propane has substantiated this supposition. However, the case depths produced in atmospheres of dilute propane are extremely shallow and their usefulness in many applications involving wear is doubtful, especially where dimensional tolerances are critical. Case depths appear to be limited to not more than several ten-thousandths of an inch in thickness – a condition that is probably the result of the low solid solubility of carbon in titanium. In general, the commercial usefulness of carburizing treatments appears to be limited.

Hardening by Hydrogen – The effect of hydrogen on the mechanical and physical properties of titanium had not been completely evaluated at the time this phase of the experiments was undertaken. Therefore, knowledge of the effect of hydrogen on surface hardening characteristics was deemed necessary.

Hydrogen treatments did increase the surface hardness, but also resulted in serious embrittlement. The average surface hardness of the material treated above 1600° F. was about Vickers 500, and was relatively shallow. Many samples treated above 1400° F. developed cracks normal to the edge. Because of these deleterious effects hydrogen treatments were abandoned.

Hardening by Boron – Several of the more common methods of "boronizing" first considered, namely, from metal-organic salts or boron hydrides, are complicated by the presence of rather large quantities of oxygen, nitrogen, carbon, or hydrogen. With a view toward minimizing the effect of these metalloid elements, the feasibility of the addition of boron from the electrolysis of fused borax was studied. The basic experiment described in a paper by Kawakami and Komuro ("Cementation of Boron on Iron and Steel by Electrolysis of Fused Borax", *Nippon Kinzoku Gakkai-Si*, Vol. 13, August 1941, p. 5-19) suggested an approach applicable to the program at hand. Several probable mechanisms involving the electrolytic treatment of titanium in molten borax have been

Fig. 4 – (A) Cathode Specimen Obtained After 2 Hr. at 1550° F. With a Current Density of 1 Amp. Per Sq. In., Cooled Slowly. Average thickness of white layer is 0.0004 in. (B) Cathode specimen after 2 hr. at 1750° F., current density 1 amp., slow cool. Average thickness of white layer 0.0012 in. 250×

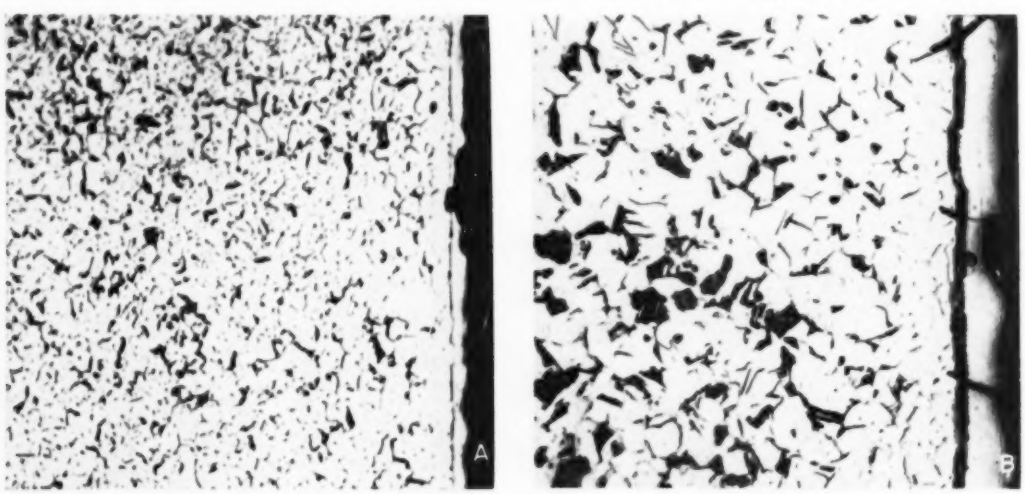


Table I – Cases Produced by Boronizing

Treatment of Samples	Vickers Hardness†	
	Surface	Core
Treated at 1550° F. for 2 hr.*	1472	176
Average case depth 0.0004 in.	1310	178
See Fig. 4A	1288	175
	1354	175
	1505	178
Treated at 1750° F. for 2 hr.*	1033	178
Average case depth 0.0012 in.	1187	180
See Fig. 4B	1402	174
	1533	181
	1505	181

*Current density 1 amp. per sq. in.
†Determined with Tukon microhardness tester. 100-g. load, 4-mm. lens

proposed by the author, and are described in detail in the "Final Technical Report on Surface Hardening of Titanium With Metalloid Elements", by R. W. Hanzel, Armour Research Foundation, Contract No. DA-11-022-ORD-289, Project No. TB4-15, June 1951-May 1953 for Watertown Arsenal, Watertown, Mass.

The following general conclusions were drawn after a study of the chemistry involved:

1. The electrolysis of borax yields sodium at the cathode during the initial stages.

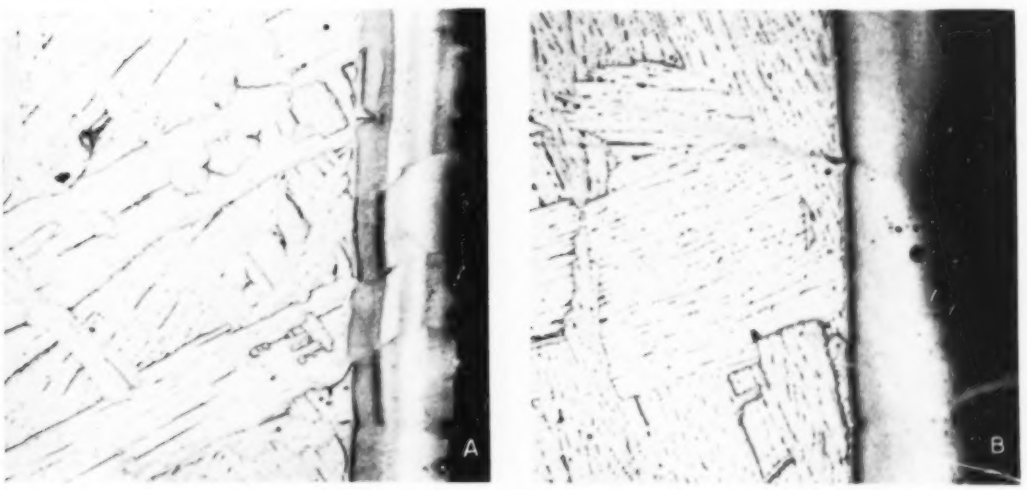
2. The free sodium then reacts with the surrounding bath and liberates boron, which migrates to the cathode and is deposited.

Temperature and current density are considered the critical variables in the operation of this process. The temperature is 1616° F.; below this, the boiling point of sodium, the bath is too viscous for electrolysis to proceed at a desirable rate, if at all. Above 1616° F., a large quantity of sodium is lost through a vigorous bubbling action and, therefore, does not have a chance to react with the boron oxide in the bath. Diffusion rates in the electrolyte are directly related to the current density. A high current drives the precipitated boron to the anode, where it is burned. Therefore, current density was 10 amp. per sq. dm.

Figures 4A and 4B illustrate the typical case developed by this treatment. All samples which were treated produced surface hardnesses ranging between Vickers 1200 and 1500. The surface and core hardnesses of several samples treated by this process are given in Table I. While an extremely hard surface is developed on the titanium by this process, the usefulness of the product is questionable because of its shallow case and rough surface.

Hardening by Nitrogen – The treatment of titanium and its alloys in an atmosphere of purified nitrogen gas appears to be the most promising of the various treatments applied. The

Fig. 5 – (A) Sample Treated for 16 Hr. at 1800° F. in Purified Nitrogen. Average thickness of case is 0.0028 in., average Vickers hardness (100-g. load) 870. Composition of gray intermediate zone unknown. (B) Treated for 16 hr. at 2000° F. in purified nitrogen. Average thickness of layer 0.0032 in., average Vickers hardness (100-g. load) 900. No gray layer between case and core; case brittle at edges. 250×



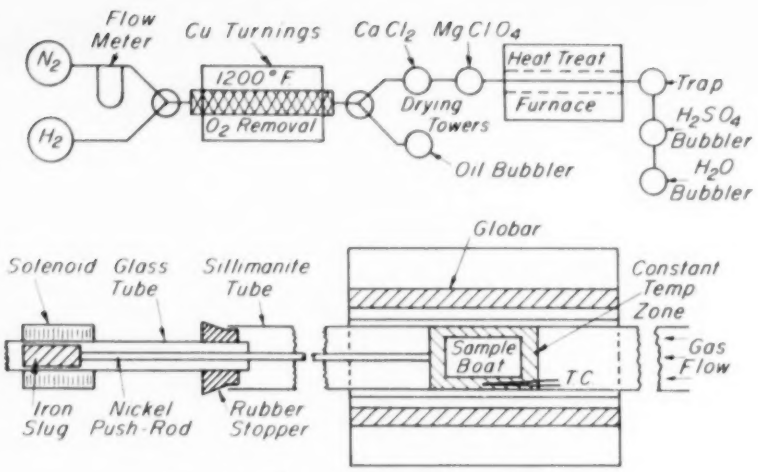


Fig. 6 — Schematic Diagram of Equipment Used for Treatments With Purified Nitrogen

samples treated in the range of 1600 to 2000° F. show some evidence of brittleness in the diffusion layer, but embrittlement of an entire ½-in. cube has not been observed. The hardened surface layer appears to be well bonded to the core. Therefore, by controlling its thickness, useful surface conditions should be developed.

The nitrogen concentration gradient is related to the time and temperature of treatment. Time ceases to have a significant effect on the depth of penetration after approximately 16 to 20 hr. of treatment in the temperature range considered in this work (1000 to 2000° F.). However, treatments at 1500° F. and higher are needed to produce cases of appreciable thickness. This case depth increases with increasing temperature, but extreme brittleness of the case is evident after treatment above 2000° F. The case depth obtained with treatments at 1500 to 2000° F. varies between 0.002 in. for the low temperature, to approximately 0.005 in. for the higher temperature. Treatments involving times up to 72 hr. and longer failed to increase the average depth of cases by more than 0.001 in.

A preliminary investigation of the nature of the case by X-ray diffraction has indicated the presence of Ti_xN, and alpha-titanium solid solution, the latter being the predominant phase. The c parameter of the alpha solid solution was approximately 4.74 Å, which is considerably higher than that for pure titanium. This corresponds to approximately 9% nitrogen in solid solution reported by Ehrlich in "On the Binary Systems of Titanium With the Elements Nitrogen, Carbon, Boron and Beryllium", *Zeitschrift für Anorganische Chemie*, July 1949, p. 11. The case is the light-etching band shown in Fig. 5.

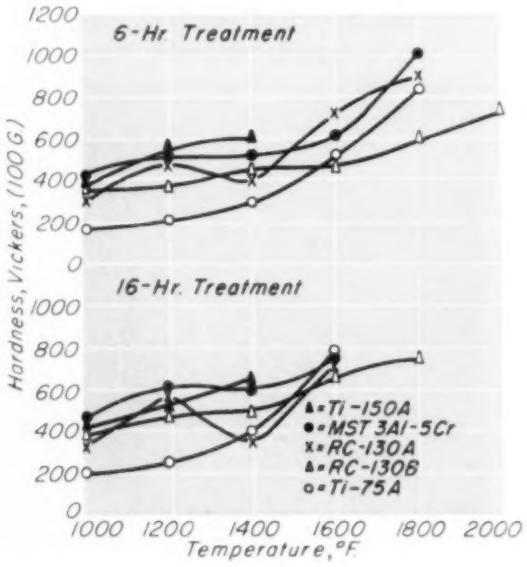
Frequently, grain boundaries of the underlying alpha grains are observed running across the interface into the case.

The conditions regarded as most beneficial at this time are treatments in purified nitrogen for 16 hr. at 1600° F. Under these conditions, the average surface hardness developed is Vickers 800, and the case depth ranges between 0.0024 and 0.0028 in. thick.

The treatment of samples in purified nitrogen was done in a Globar furnace containing a sillimanite tube. The furnace, in conjunction with control equipment, is capable of maintaining a constant temperature zone (1 in. long) to within ± 5° F.

Water-pumped tank nitrogen was passed over hot copper turnings (1200° F.) to remove oxygen. A series of calcium chloride and magnesium perchlorate desiccants removed entrained moisture. The maximum dew point was −94° F., and a gas flow of 0.75 cu. ft. per hr. was

Fig. 7 — Surface Hardness Versus Temperature for Unalloyed Titanium (Ti-75A) and Several of Its Alloys Treated in Purified Nitrogen. Original Vickers hardnesses of samples (½-in. square) averaged 180 for Ti-75 A, 351 for Ti-150 A, 340 for RC-130 A, 340 for RC-130 B, 363 for MST-3Al-5Cr



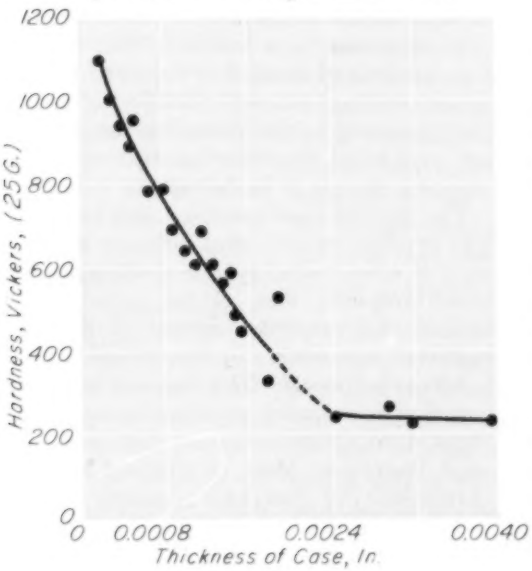
maintained at all times. A schematic diagram of the equipment is shown in Fig. 6.

A protective atmosphere was maintained while the titanium specimen was introduced into the hot zone of the furnace. Positioning of the sample was done by a solenoid which acted on an iron armature located in the exit portion of the gas flow tube and which was a part of the nickel pushrod attached to the sample boat as illustrated in the schematic diagram. Breaking of the gas train occurred only when the sample was inserted or removed, this being done while the boat was in the cool portion of the tube. After a sample was placed in the boat to recharge the furnace, the tube was purged for ½ hr. and the boat was pushed into the hot zone. This procedure was reversed when the run was completed.

EVALUATION OF NITROGEN TREATMENTS

Surface hardness data are presented in Fig. 7 for unalloyed titanium Ti-75A, and the commercial alloys Ti-150A, RC-130A, RC-130B, and MST-3A1-5Cr. All specimens were treated for 6 and 16 hr. between 1000 and 2000° F. in increments of 200° F. in an atmosphere of purified water-pumped tank nitrogen. Figure 8 is a composite plot of four hardness traverses on a sample of unalloyed titanium treated for 16 hr. at 1600° F. The average thickness of the case was approximately 0.0024 in. Comparison of this plot with the structure shown in 5A revealed that the location of interface of the case and the core corresponds approximately with the region where a sharp change of slope occurs. With treatments above 1600° F., this interface is possibly coincident with the boundary between co-existing alpha and beta phases. Therefore, the known differences in the hardening characteristics of these two phases, and their individual and combined effect on the phase boundary, make reliable hardness measurements difficult to obtain. For this reason, the lines are not joined, but rather dotted to indicate the relative uncertainties of the nature of this critical area. It should be noted that the load on the indenter used for this particular hardness testing was 25 g. As a result, the maximum surface hardness would appear to be near Vickers 1200 when the curve is extrapolated. This does not agree with the surface hardnesses plotted in Fig. 7. Before surface hardness measurements are made, however, a surface film must be removed to obtain a suitable reflecting surface; this combined with the penetration of the indenter under higher loads is thought responsible for the discrepancy.

Fig. 8 – Hardness Gradient for Unalloyed Titanium (Ti-75 A) Treated for 16 Hr. at 1600° F. in Purified Nitrogen. Original hardness averaged Vickers 180.



On the basis of the data plotted in Fig. 7, it is apparent that the surface hardening characteristics of the commercial alloys conform to the general hardening characteristics established for unalloyed titanium.

Hardening With Ammonia – Preliminary work carried on at the Armour Research Foundation on ammonia nitriding indicated that the results would be similar to those for treatments with nitrogen gas. Process variables, flow rate, dissociation and other factors have not been completely evaluated, but it is anticipated that they will have a pronounced effect. It should be noted, however, that considerable quantities of hydrogen are present, and that in view of results obtained with the hydrogen gas treatments, the mechanical properties of the treated material may be substantially altered.

Similar work has been reported previously ("Titanium Can Be Case Hardened by Nitriding", by E. J. Silk, *Iron Age*, Nov. 13, 1952, p. 166 to 170), and hardnesses and case depths agree, in most part, with data reported herein for nitrogen gas treatments.

Hardening of Special Alloys With Nitrogen – Some work was directed toward the development of titanium alloys that would be particularly amenable to surface hardening. The original intention of alloying was to produce a hardening effect by a nitride dispersion, in addition to the solid solution hardening. Among

the alloying elements chosen because they form very stable nitrides are boron, vanadium, chromium, zirconium, aluminum and columbium. Carbon was included in this series of special alloys to improve the understanding of the surface hardening effects of this element. While the ability to produce such an alloy dispersion was doubtful, thermodynamic data indicated the possibility that some of these alloying elements might form stable nitrides in the presence of titanium.

All of the special titanium-base alloys thus far treated show little or no increase in the surface hardness of unalloyed titanium, with the exception of the following:

1. Titanium alloyed with 3 at. % of boron treated for 6 hr. and longer at 1200° F.
2. Titanium alloyed with 3 at. % of vanadium treated for 16 hr. at 1200° F.
3. Titanium alloyed with 5 at. % of vanadium and treated for 6 hr. and longer at 1200° F.

Figure 9 shows hardening characteristics of these alloys relative to the hardness of unalloyed titanium.

The reason for these alloys showing strong surface hardening characteristics at the low temperature of 1200° F. is not known at this time. Metallographic examination of the specimens revealed no apparent structural condition that could be responsible for this effect. The alloys are essentially two-phase at room temperature; however, the hardening pattern appears to be independent of the size and distribution of the second phase. It would seem to follow, therefore, that this increased hardening is due to an irregularity in the known solid solution hardening effect of nitrogen.

Conclusion – Titanium and its alloys harden when heated in air, but the product is not useful because of excessive scale and brittleness. Gas and pack carburizing of titanium as described herein produced rough, porous, loosely adhering surface layers. Brittleness resulted from treatment at 1400° F. and above. Hydrogen treatments increase the surface hardness and cause serious embrittlement. The surface hardening effect is low and the affected zone is shallow. An extremely hard surface is developed on titanium by an electrolytic treatment in molten borax. The usefulness of the product is questionable, however, because of its shallow case and rough surface.

The purified nitrogen treatment of unalloyed titanium, several special titanium-base alloys, and several commercial alloys develops a relatively hard, adherent case between 1500 and 1800° F. The properties appear to be adequate for a practical surface hardening process. At this time, the best treatment consists of heating for 16 hr. at 1600° F.

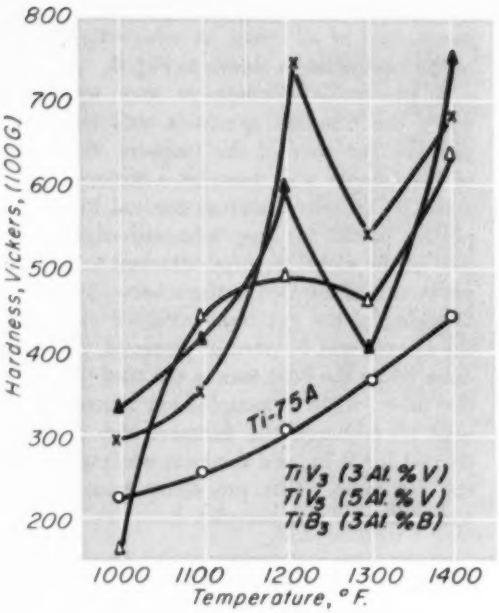


Fig. 9 – Comparison of Unalloyed Titanium With Titanium-Base Alloys of Vanadium and Boron After Treatment in Purified Nitrogen for 24 Hr. Original Vickers hardnesses of samples (½-in. square) averaged 199 for TiV_3, 275 for TiV_5 and 234 for TiB_2

The average surface hardness developed is Vickers 800, with case depth ranging between 0.0024 and 0.0028 in. Wear evaluation (preliminary results indicate excellent resistance) of such cases is being studied under a separate contract. Results of this wear program will be reported at a later date.

Investigations have indicated that the surface hardness of titanium is improved by ammonia nitriding. Although the effect of hydrogen introduced by this process on the physical and mechanical properties has not been evaluated, it is thought to be deleterious.

The titanium-base vanadium and boron alloys develop optimum hard, adherent cases at 1200° F. when treated in purified nitrogen. With these exceptions, none of the special alloys yielded case properties superior to those of unalloyed titanium at this temperature.

Acknowledgments – This paper is based on part of an investigation sponsored by the United States Army Ordnance Corps, Watertown Arsenal, Watertown, Mass., on Contract No. DA-11-022-ORD-289. Permission to publish is gratefully acknowledged. Metallographic work was done by C. A. Johnson.

Product Purity and sterility are easy to maintain in this metering pump, because head and inlet and outlet fittings are constructed of Type 303 chromium-nickel stainless steel. Maisch Metering Pumps are built by Mechanical Products Corp., Chicago 7, Ill.

An example of Corrosion Resistance
...and maintenance of accuracy...
provided by Type 303 Stainless

Manufacturers of equipment designed to protect product purity and assure sanitation find it pays to use chromium-nickel stainless steel for corrosion resistance and other money-saving properties.

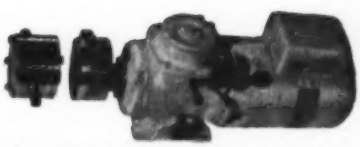
For instance, the makers of Maisch metering pumps . . . widely used for precise dispensing in biological and industrial fields . . . specify Type 303 Stainless. They fabricate pump heads and inlet and outlet fittings from Type 303 to provide properties that help users maintain product purity, sterility and sanitation, as well as permanent accuracy under very diverse service conditions.

Type 303 is the free-machining grade of the austenitic chromium-nickel stainless steels which are immune to most organic and a great many inorganic chemicals.

This improved machinability, combined with resistance to galling and seizing, make Type 303 stainless particularly useful for gears, heads, fittings and other machined products.

You can also trim bulk and deadweight by using correct types of chromium-nickel stainless. They are strong yet tough, and also resistant to wear and abrasion. At elevated temperatures they resist creep, scaling and oxidation, while at low temperatures they offer exceptional resistance to impact.

Investigate all the economies you can obtain by using stainless steel for your products or equipment. Send us your inquiries on the use of cast or wrought stainless alloy steels containing nickel, and details of your problems for our suggestions.



Chromium-Nickel Stainless Steel Type 303 . . . and precision construction . . . contribute to the permanent accuracy of this biological metering pump. Maisch pumps are adjustable, and permit dispensing from 0 to 9,000 cubic centimeters per minute.

Sanitation in dispensing hot or cold, viscous or non-viscous liquids is advanced by use of Type 303 stainless. Maisch industrial pumps are available, single or duplex, with fixed capacities from 10 to 290 gph.

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Directory of Degree Programs in Metallurgy

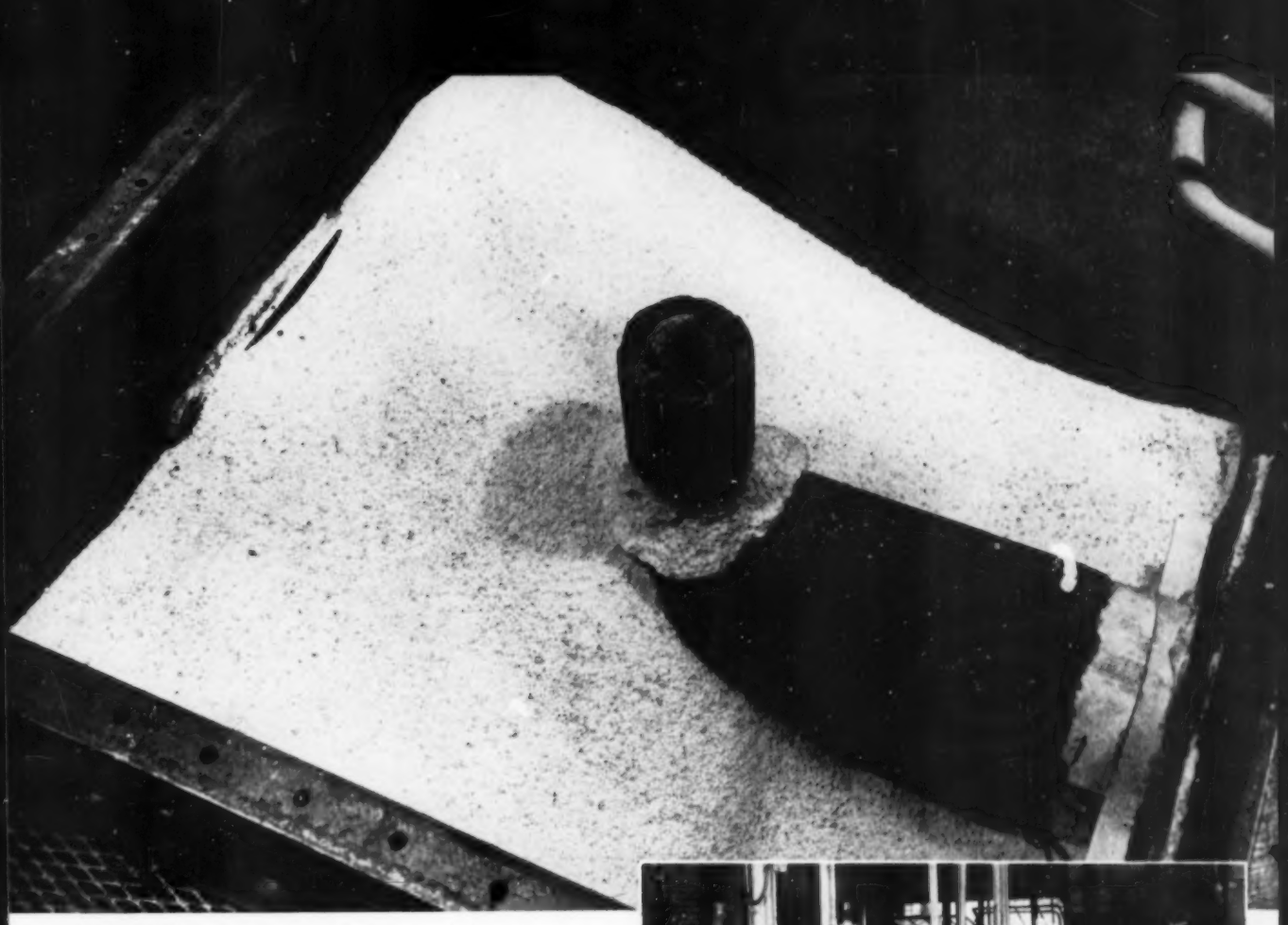
UG indicates that undergraduate degrees were awarded in 1952-1953;
PG that postgraduate degree programs are offered.

Compiled by A. Bornemann

STATE	SCHOOL OR UNIVERSITY	LOCATION	DEPARTMENT	IN CHARGE	PROGRAMS
Alabama	University of Alabama	University	Metallurgical Eng.	E. C. Wright	UG & PG
Arizona	College of Mines, U. of Ariz.	Tucson	Mining & Met. Eng.	J. B. Cunningham	UG & PG
California	University of California	Berkeley	Div. of Mineral Tech.	A. Carlson	UG & PG
	Calif. Institute of Technology	Pasadena	Engineering Division	F. C. Lindvall	PG
	Naval Postgraduate School	Monterey	Metallurgy & Chem.	F. L. Coonan	PG
	Stanford University	Palo Alto	Div. of Mineral Tech.	O. Cutler Shepard	UG & PG
Colorado	Colorado School of Mines	Golden	Metallurgy		UG & PG
Connecticut	Yale University*	New Haven	Metallurgy	Arthur Phillips	UG & PG
Florida	U. of Fla., College of Eng.	Gainesville	Mechanical Eng.	W. T. Tittin	PG
Idaho	University of Idaho*	Moscow	Metallurgy	A. W. Fahrenwald	UG & PG
Illinois	University of Illinois	Urbana	Mining & Met. Eng.	H. L. Walker	UG & PG
	Illinois Institute of Technology	Chicago	Metallurgical Eng.	Otto Zmeskal	UG & PG
Indiana	University of Notre Dame	South Bend	Metallurgy	E. A. Peretti	UG & PG
	Purdue University	Lafayette	Chem. & Met. Eng.	E. W. Comings	UG & PG
Kansas	University of Kansas	Lawrence	Mining & Met. Eng.	K. E. Rose	UG & PG
Kentucky	University of Kentucky*	Lexington		C. S. Crouse	UG & PG
	University of Louisville	Louisville	Chemical Eng.	G. C. Williams	PG
Maryland	Johns Hopkins U., School of Eng.	Baltimore	Mechanical Eng.	R. Maddin	PG
Massachusetts	Harvard University†	Cambridge	Div. of Applied Science	Bruce Chalmers	PG
	Mass. Institute of Technology	Cambridge	Metallurgy	John Chipman	UG & PG
Michigan	University of Michigan*	Ann Arbor		D. L. Katz	UG & PG
	Mich. College of Mining & Met.*	Houghton		C. T. Eddy	UG & PG
	Michigan State College	Lansing	Metallurgical Eng.	Austen J. Smith	UG & PG
	Wayne Univ., College of Eng.	Detroit	Chem. & Metallurgy	James R. Taylor	UG & PG
Minnesota	School of Mines & Metallurgy	Minneapolis	Metallurgy	R. L. Dowdell	UG & PG
Missouri	School of Mines & Metallurgy	Rolla	Metallurgical Eng.	A. W. Schlechten	UG & PG
Montana	Montana School of Mines	Butte	Metallurgy	F. A. Hames	UG & PG
Nebraska	University of Nebraska	Lincoln	Mechanical Eng.	W. F. Weiland	PG
Nevada	University of Nevada†	Reno	Mining & Metallurgy	J. A. Carpenter	UG & PG
New Jersey	Stevens Institute of Technology	Hoboken	Metallurgy	A. Bornemann	PG
New Mexico	N. M. Inst. of Mining & Tech.	Socorro	Mining & Metallurgy	A. J. Thompson	UG
New York	Columbia University*	New York	Mining, Mineral & Met. Eng.	Max Gensamer	UG & PG
	New York University	New York	Chemical Eng.	John Nielson	UG & PG
	Cornell University*	Ithaca	Chem. & Met. Eng.	P. E. Kyle	UG & PG
	Rensselaer Polytechnic Inst.	Troy	Metallurgical Eng.	Wendell F. Hess	UG & PG
	Polytechnic Inst. of Brooklyn	Brooklyn	Mechanical Eng.	E. L. Midgette	UG & PG
North Dakota	U. of North Dakota†	Grand Forks	Mining Engineering	L. C. Harrington	
Ohio	Case Inst. of Technology	Cleveland	Metallurgical Eng.	A. F. Troiano	UG & PG
	University of Cincinnati	Cincinnati	Chem. & Met. Eng.	William Licht	UG & PG
	Ohio State University	Columbus	Metallurgy	M. G. Fontana	UG & PG
Oklahoma	University of Oklahoma	Norman	Mechanics & Eng. Met.	John P. Roberts	PG
Oregon	Oregon State College	Corvallis	Mechanical Eng.	O. G. Paasche	PG
Pennsylvania	University of Pittsburgh*	Pittsburgh	Metallurgical Eng.	J. Alfred Berger	UG & PG
	Drexel Inst. of Technology	Philadelphia	Metallurgical Eng.	A. W. Grosvenor	UT
	Carnegie Inst. of Technology	Pittsburgh	Metallurgical Eng.	R. F. Mehl	UG & PG
	University of Pennsylvania	Philadelphia	Metallurgical Eng.	R. M. Brick	UG & PG
	Lehigh University	Bethlehem	Metallurgical Eng.	Allison Butts	UG & PG
	Pennsylvania State College	State College	Division of Metallurgy	Amos J. Shaler	UG & PG
	Lafayette College	Easton	Mining & Met. Eng.	L. D. Clark	UG
South Dakota	S.D. School of Mines & Technology	Rapid City	Metallurgical Eng.	G. R. van Duzee	UG & PG
Tennessee	University of Tennessee	Knoxville	Chemical Eng.	E. E. Stansbury	UG & PG
	Vanderbilt University	Nashville	Chemistry	W. P. Fishel	PG
Texas	Texas Western College, U. of Texas	El Paso	Mining & Metallurgy	J. C. Rintelen, Jr.	UG
Utah	University of Utah	Salt Lake City	Metallurgical Eng.	John R. Lewis	UG & PG
Virginia	Virginia Polytechnic Inst.	Blacksburg	Metallurgical Eng.	H. V. White	UG & PG
Washington	School of Mines, State College	Pullman	Metallurgy	J. P. Spielman	UG & PG
	University of Washington	Seattle	Metallurgy	E. A. Rowe	UG & PG
West Virginia	West Virginia University	Morgantown	Chemical Eng.	H. V. Fairbanks	PG
Wisconsin	University of Wisconsin	Madison	Mining & Metallurgy	E. R. Shorey	UG & PG

*Information from subsequent inquiry (short form of original questionnaire).

† From catalogues, data not included in tabulation or discussion.



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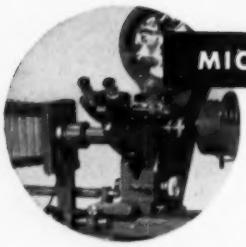

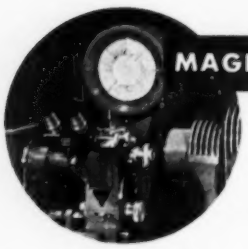

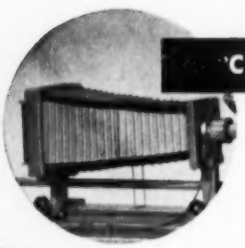

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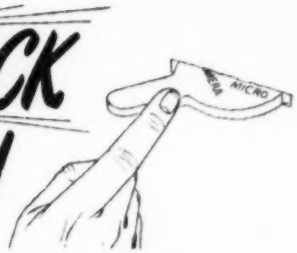

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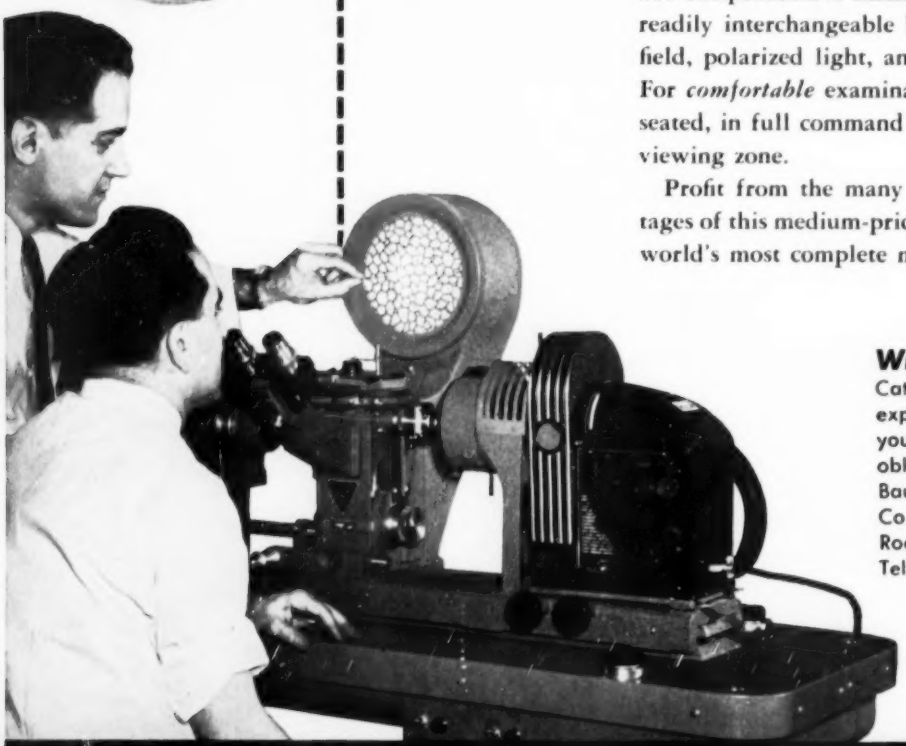

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Metallurgical Education in the United States

By ALFRED BORNEMANN
Professor of Metallurgy
Stevens Institute of Technology
Hoboken, N. J.

SINCE the American Society for Metals is an organization of engineers and executives in the metallurgical industries, it is naturally concerned with the educational facilities and processes through which technically trained personnel are prepared. A few years ago, a list of schools teaching metallurgy was required by the ASM's Committee on Metallurgical Education. A search failed to disclose a recently compiled one and, as the need was urgent, another was drawn up on the basis of information which could be rapidly received from various sources. Unfortunately, some schools were omitted from this list, and others, not giving degree courses in metallurgy, included. There was an obvious duty to become better informed.

In order to obtain correct, up-to-date information, the ASM Committee on Metallurgical Education circulated a questionnaire in December of 1952* to all accredited colleges, universities and schools of technology in this country. The questionnaire was quite comprehensive and this report will only analyze the answers received in regard to questions concerning degree and postgraduate courses, number of undergraduate and postgraduate students, degrees awarded in 1952, number of men on metallurgical faculty and research staff. Some of the results of this questionnaire have been summarized in the tables. Where the data were incomplete, information was obtained from a follow-up in shorter form which requested fewer details. Some interesting facts have been disclosed, a few of which will be discussed in the following paragraphs. Any comments which appear to be interpretive are the author's and do not necessarily reflect the opinion of the ASM Committee.

As best as could be ascertained from the questionnaire and other sources, and as listed in the Data Sheet, p. 96-B, there are 59 schools in this country offering undergraduate or postgraduate degree courses in metallurgy. Our survey did not try to draw a distinction between various special fields of metallurgy, such as physical, chemical, process, adaptive, or extractive. Ten of the 56 schools responding to the survey offer only postgraduate degree courses, whereas five of the 46 offering undergraduate programs do not undertake any instruction on the postgraduate level.

TRADITION AND DEVELOPMENT

In 1941 Prof. T. T. Read of Columbia published an exhaustive study of "The Development of Mineral Industry Education in the United States" in the *Transactions* of the American Institute of Mining and Metallurgical Engineers. His most recent statistics are for the year 1938-1939. He mentioned 49 institutions which offered mineral industry education and 46 of these appear on our present list

*EDITOR'S NOTE — At the time, Professor Bornemann was chairman of the ASM Committee. The analysis of the returns was made by him, and this article should not be interpreted as a formal report of the ASM Committee on Metallurgical Education.

of 59 schools. Thus it is apparent that 13 schools have added metallurgical undergraduate or graduate degrees to their programs in the past 13 years, and three may have dropped instruction or never gave any in metallurgy. Ten of the 13 new schools are in large manufacturing regions where many engineering research and development laboratories are located. These schools teach little, if any, process metallurgy. Professor Read makes the point several times that the environment in which a school is situated seems to influence its character and success. Recent developments in metallurgical engineering education tend to bear this out and bring little comfort to those who are working hard to find good men to take jobs in the field of *process* metallurgy.

Metallurgy is associated with mining both in the lay mind and in scholastic organizations. As the science of chemistry developed, certain schools grouped metallurgy and chemistry together because they seemed to have so much in common. In some places, chemistry or mechanical engineering departments first fostered and supported the teaching of metallurgy. It is quite evident that this process is still going on, as a glance at the names departments have will indicate. These names and the number of times each is used, along with the number of seniors and postgraduate students enrolled in degree programs in metallurgy sponsored by these departments, appear in Table I. Happily, it is apparent that there is plenty of recognition of the independent status of metallurgy, both on the part of school administrators and students. The word "Engineering" occurs in the names of about one half the departments described in the first three large groups in Table I, but it has been omitted as a separate item in the tabulation.

Table II summarizes the enrollment statistics obtained from our questionnaires. These check fairly well with those collected in 1950-1951 by Robert C. Story of the Federal Security Agency, U.S. Government Office of Education, which show that 590 first degrees, 236 M.S. degrees and 24 Doctor's degrees in metallurgy were awarded by schools having curricula in metallurgy accredited by the Engineers' Council for Professional Development. In all mineral industry courses, ceramics, geological, metallurgical and mining (excluding petroleum), there were 1594 first degrees in 1950-1952. In 1939 Read found that there were 1434 candidates for the bachelor's degree in mineral technology. It is quite clear from the foregoing statistics that those answering the ⊖ questionnaire had only metallurgy in mind and not any other branch of the mineral industries field.

Table I — Department Names and Enrollment in Relation to Names

Name of Department	Frequency	Students in Metallurgy	
		'53 Seniors	Postgrads
Metallurgy	23	342	468
Mining and Metallurgy	7	79	68
Minerals Technology	2		
Metallurgy and Chemistry	4	59	47
Mechanical Engineering	5	9	45
Chemical Engineering	4	13	49
Others	3	0	13
Totals	48	502	690

What is Metallurgical Engineering?

It is interesting to note that the U.S. Government Office of Education classified a B.S. in Metallurgy as a degree in one of the physical sciences, whereas a Metallurgical Engineering degree was classified under degrees conferred in "all other engineering". There is, even in academic circles, a lack of agreement as to what constitutes metallurgy. A recent classification is contained in a report of an American Society for Engineering Education's committee which analyzed mineral engineering curricula:

1. Mineral Exploration Engineering
   - 1.1 Mining and Engineering Geology
   - 1.2 Geophysical Engineering
2. Mineral Production Engineering
   - 2.1 Mine and Quarry Engineering
   - 2.2 Petroleum and Natural Gas Engineering
3. Mineral Process Engineering
   - 3.1 Metallurgical Engineering
   - 3.2 Mineral Dressing
   - 3.3 Ceramic Engineering

The metallurgy which is the bread and butter of most ⊖ members deals with the processing, fabrication and treatment of metals, or metallic components, so that the finished product will fulfill its function most efficiently. This is hardly a field of interest subordinate to "Mineral Process Engineering", Class 3 of the above tabulation.

John Chipman, past president of ⊖, discussed this problem in an article in *Metal Progress* in August 1948, and proposed the outline shown in Table III, which is certainly more in accord with today's interests. This outline contains two major departments designated as Metallurgical En-

gineering and Metallurgical Science.

Some day, we may be able to define what we are. It would be well to do so because otherwise statistical compilation of human activities will never truly reflect the important role the members of our Society play in modern life.

There can be no question as to which came first, the mineral or the metal, yet it would seem that our profession is at last cutting itself off from its maternal apron strings. This is indicated by the fact that an overwhelmingly large proportion of students in metallurgy are instructed by departments of metallurgy, and this metallurgy is something apart from Mining or Geological Science or Engineering. Hence the outline suggested by the American Society for Engineering Education is not very realistic.

Certainly, the practising metallurgists in today's industry have had no common undergraduate experience. It is a rare event if, among a group discussing their undergraduate degrees, more than a small fraction say they have "studied metallurgy" – meaning that they passed through a definite undergraduate curriculum. Most of them take it up as a postgraduate study, or enter the profession because they find an opportunity for work and advancement.

There is a growing recognition of the merit in a general scientific-professional course for many engineering undergraduates, topped by postgraduate work in special fields for a few. Metallurgy is certainly a good field for postgraduate study and the answers to the ⊕ questionnaire underscore the current emphasis on metallurgy as an interesting and worth-while field of postgraduate study. When one deducts from the total number of postgraduates enrolled an estimated number studying evenings and holding daytime jobs in industry, it appears that approximately 600 young men are currently engaged in postgraduate work, research and teaching on a full-time basis.

Much of the research now being done in schools and universities is financed by the Government. Most of the graduate students work on parts of this research (or teach part-time) to support themselves financially. Very few are on their own – excepting those who attend evening classes, and even there many such students receive some subsidy from their employers if their performance is satisfactory.

Table III – Chipman's Outline of Metallurgy

Metallurgical Engineering	Metallurgical Science
I — Mineral Dressing	**I — Chemical Metallurgy**
1. Comminution of ores	1. Crystal chemistry and mineralogy
2. Separation of minerals	2. Thermodynamics of systems and processes
3. Leaching	3. Reaction kinetics
II — Process Metallurgy	4. Surface chemistry
1. Roasting and sintering	5. Corrosion and electrochemistry
2. Reduction and smelting	**II — Physical Metallurgy**
3. Fuels and combustion	**II-a. Metallography**
4. Heat and fluid flow	1. Structure of alloys
5. Electrometallurgy	2. Equilibria in metallic systems
6. Melting, refining and alloying	3. Recrystallization and grain growth
7. Casting and solidification	4. Reactions in the solid state
III — Metal Processing	**II-b. The Physics of Metals**
1. Hot and cold forming	5. Atomic and electronic structure
2. Foundry practice	6. Diffusion
3. Joining	7. Electrical and magnetic properties
4. Surface treatment	8. Theory of the solid state
5. Powder metallurgy	**II-c. Mechanical Metallurgy**
6. Heat treatment	9. Elastic and anelastic behavior
IV — Application Metallurgy	10. Plastic flow and fracture
1. Selection and specification	
2. Alloy design	
3. Quality control	
4. Service behavior	

STUDENT AND FACULTY RESEARCH

The metallurgical industries and the ⊕ should keep a close watch on this situation. Between the two of them, ways may have to be devised to help the colleges keep promising men in postgraduate schools, should changes in governmental policies or tax struc-

Table II – Enrollment and Degrees Awarded in 1952 and 1953

ASM Questionnaire	Number Answering	Undergrad. Degrees		Postgraduate				
				Total No. Enrolled	Goal		Degrees 1952	
		1952	1953		M.S.	Ph.D.	M.S.	Ph.D.
Long form	48	508	502	690	408	282	116	60
Short form	8	*	87	190	130	60	*	*
Totals	56	*	589	880	538	342	*	*

*Answers could not be obtained from short form of questionnaire.

tures curtail present practices of financing industrial research in metals.

Some of the most interesting facts brought out by this survey deal with the sizes of the groups for which schools organize degree courses. Certainly no one can accuse metallurgical educators of mass production. The size of senior classes can be judged by the number of metallurgical degrees awarded in 1952:

15 schools awarded 5 or fewer degrees
12 schools gave between 6 and 10 degrees
7 schools gave between 11 and 20 degrees
9 schools gave between 21 and 30 degrees
4 schools gave more than 31 degrees (31, 33, 38 and 40 respectively).

With regard to graduate degree courses, the treatment must be a very personal one. In 1952, 25 schools awarded only one or two Master's degrees; seven schools awarded between three and five; two gave between six and ten and one awarded more, 29.

Doctor's candidates received the same individual treatment: 11 schools awarded only one or two degrees; eight awarded three to five degrees; only one school gave more than five and this one awarded 17.

This is really a remarkable educational phenomenon. It would seem to indicate exceptional devotion on the part of teachers to their jobs, and a great sense of duty on the part of school administrators. The educational processes are really dispensed lovingly under conditions which must often discourage those doing the job because so few benefit from the effort required to develop and conduct a course.

An attempt was made to get some idea of the activities of the faculty members responsible for metallurgical instruction. The information obtained is reproduced below.

Faculty Activities (1952-1953)

		Reporting:	Total
Schools questioned		34	56
Total seniors and postgraduates		974	1469
Personnel			
Professors	165		
Instructors	40		
Researchers	148		
Technicians	131		
Total staff		484	
Activities*			
Teaching		170 man-years	
Research		298	
Administration		16	

*Part-time activities were prorated.

Data from more than half of the 56 schools that answered the questionnaire could be satisfactorily interpreted for this purpose. It can be seen that schools are actively contributing their resources, both human and physical, for the benefit of the metallurgical industries. Some schools naturally do much more than others, but looking at the whole picture we may well be proud of the role our schools are playing in achieving a balance between the dissemination of knowledge and the extension of the frontiers of metallurgical science by research.

WHERE DO WE GO FROM HERE?

The collected data suggest some thoughts regarding educational facilities in metallurgy and the role they might play in meeting the great demand for metallurgists. It is obvious that many more students could be handled in metallurgical programs now established. Well-trained teachers and facilities would permit a considerable expansion of the student body, especially in those schools now graduating very few men with first degrees. Instructional staffs could also be expanded if people now engaged in research activities were to devote more of their time to teaching.

The American Society for Metals, representing the largest number of metallurgists in the world, has taken active steps to increase enrollment in engineering schools. It has fostered interest at the junior and senior high school levels by sponsorship of a program of awards for science students and teachers, conducted by National Science Teachers Association, and by the publication of the widely circulated pamphlet "A Career in Metallurgy". Many of the local chapters send representatives to their high schools and interest the students in metallurgy as a life work. At the college level, the ⊜ is sponsoring scholarships for undergraduate students enrolled in degree programs, and has opened its doors to students by offering them the privilege of junior membership with its attendant benefits. It is encouraging college faculty members by teaching awards, by financing visiting lectureships, and by organizing the "Seminar Week-End" exhaustively treating a fundamental subject just ahead of the annual convention.

Seldom has an engineering society made such a strenuous effort to perpetuate itself, and it is to be hoped that the next report of this kind will show the benefits of this activity, which certainly represents a strong affirmation of our faith in education. ⊜

German Investigations on Boron Steels

By ROBERT SCHERER, Chief Technical Director
and KARL BUNGARDT, Chief of Research
Deutsche Edelstahlwerke Aktiengesellschaft (German Alloy Steelworks)
Krefeld, Germany

NUMEROUS REPORTS have appeared in recent years in the foreign literature concerning the effect of small boron additions on the properties of carburizing and heat treatable steels. Many of them discuss the possible conservation of alloying elements such as chromium, molybdenum and nickel due to the increase in hardenability effected by boron additions; others deal with improved properties. Americans have given most attention to these matters, and about 100 tentative standard analyses and a number of hardenability bands have been adopted by the American Iron and Steel Institute. A comprehensive review of the situation in that country exists in the booklet "Boron Steel" recently issued by the American Society for Metals.

Substitution of a boron-treated "triple alloy" steel containing about 0.50 Ni, 0.65 Cr, and 0.10 Mo for a 3½% nickel steel in tractor axles and steering mechanisms, together with similar substitutions in other heavy parts, has enabled the Caterpillar Tractor Co., for example, to save some 12,000 tons of alloying nickel since 1940 – certainly a notable performance for a single concern. The industrial situation in Germany contains no parallel examples, primarily because most of our standardized alloy steels (comparatively few in number) differ essentially from their American counterparts not only in alloy types but in alloy combinations. Even without boron, the American trend – especially in mass production – during the last decade has been toward the use of lower alloy steels and those with fractional percentages of three alloys in combination (nickel and chromium and the least amount of molybdenum, only rarely depending on extra manganese for its alloying capabilities). American production statistics indicate that boron steels are used in largest tonnage when alloying elements are under sharpest governmental restriction. Boron steels, to achieve a lasting importance even in times of ample supply of the common alloying elements, must therefore exhibit measurable advantages in cost and ease of fabrication as well as ability to perform satisfactorily in service.

An account of German tests and experience may throw additional light on the last-mentioned considerations.*

We had acquired a body of experience during the last war with steels low in nickel and in molybdenum – even those without any and those wherein vanadium was substituted for molybdenum. So our purpose a few years ago was to evaluate the information and make some new tests for comparison with the present German standard steels.

In this work we assumed that substitutions cannot be judged solely on the basis of hardenability, irrespective of the characteristic effect of the individual alloying elements upon other properties. Furthermore, consideration must be given to the kind and quantities of alloying elements originating from the scrap and also to the economic aspects of such substitutions. Finally, the leaner alloy steels or steels of different type often compel the producer and consumer of steel to change their processes, equipment, or control limits.

We made a number of carburizing steels and heat treatable steels in basic-lined, high-frequency induction furnaces of 125 lb. capacity. Just before pouring, 1 oz. of aluminum was

*Those who read German will find much information supplementary to this brief review in *Stahl und Eisen*, Vol. 70, 1950, p. 382 and p. 1060; Vol. 71, 1951, p. 258 and p. 433; Vol. 76, 1952, p. 1433. The present authors discussed boron steels before the Société Francaise de Métallurgie in Paris, Oct. 21, 1952.

added (residual analysis was 0.01 to 0.03%). Half the melt was then cast into a small forging billet. To the other half was added 0.10% titanium as ferrotitanium, principally to fix any nitrogen dissolved in the steel and to insure the effectiveness of the boron addition.* Finally ¼ oz. of 18.4% ferroboron was stirred in and the second half of the melt cast into a billet.

In this way we had comparison heats A and B, identical as to chemical composition within the limits of analytical accuracy for soluble nitrogen, titanium and boron:

A Heats	B Heats
0.006 to 0.010 N_2	0.003 to 0.005 N_2
No Ti	0.04 to 0.11 Ti
No B	0.0030 to 0.0048 B

CARBURIZING STEELS; HARDENABILITY

A dozen split melts of carburizing steels were made within the following composition limits: 0.13 to 0.21 C, 0.22 to 0.30 Si, 0.53 to 0.60 Mn, 1.08 to 2.05 Cr, 0.58 to 2.09 Ni. "Tramp" molybdenum was 0.06 to 0.11. In the interest of brevity, only five representatives will be described; in addition we will use the German standard carburizing steels 15 Cr Ni 6 and 18 Cr Ni 8 (with and without boron) as reference norms. Analyses were as shown in Table I.

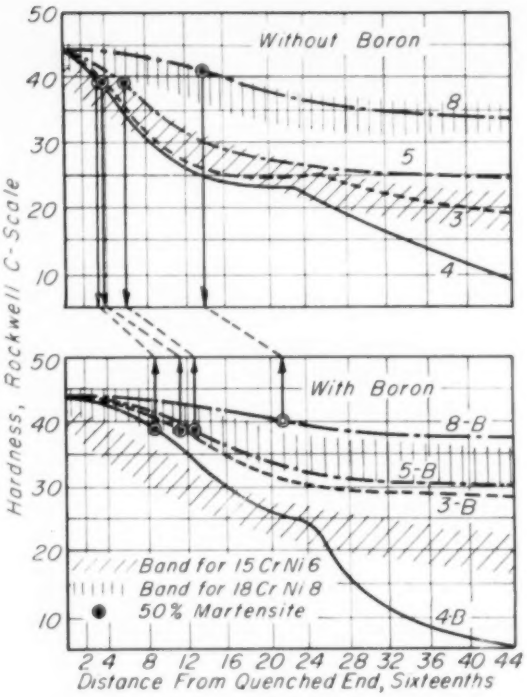
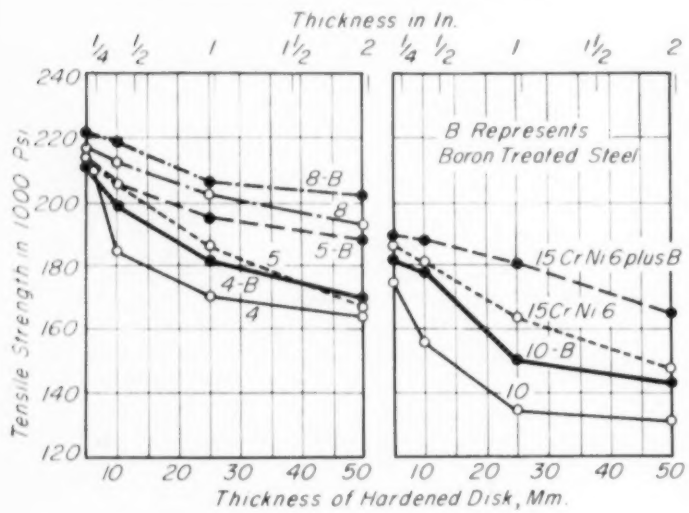


Fig. 1 – Jominy End-Quench Hardenability Curves of Experimental Steels Without Boron (Above) and With Boron (Below). Hatched bands represent spread for two German standard steels without boron. Circled points mark position of the 50% martensitic microstructure

Figure 1 shows their hardenability curves (except No. 10) and their position in relation to the hatched scatter bands of a number of production melts of standard steels 15 Cr Ni 6 and 18 Cr Ni 8. Distance from the quenched end to the zone with 50% martensite microstructure is used to compare hardenabilities, and these values are noted on the curves as well as in Table I. These data permit an estimate of the alloy savings possible by adding boron to steels of this type.

Only the boron-free steel No. 8 with 0.19% C, 2.05% Cr and 1.10% Ni falls above the hardenability of the boron-treated steel most closely approaching the curves of steel 5-B, containing about 0.18% C, 1.55% Cr, 0.85% Ni, leading to the immediate conclusion that – with respect to hardenability – about 10 lb. of chromium and 5 lb. of nickel per ton can be eliminated by the boron addition.

Fig. 2 – Tensile Strength (Hardness) of Plates of Various Thickness After Normalizing and Then Oil Quenching. Boron has pronounced benefit, as demonstrated by such "blind hardening" tests



*Experience with production heats in electric and open-hearth furnaces indicates that the ferrotitanium may be safely reduced to somewhat lower proportions.

Table I – Characteristics of Carburizing Types

Mark	C	Cr	Ni	50% Martensite	
				No B	With B
3	0.19	1.08	1.10	4	11
4	0.20	1.15	0.58	4	9
5	0.18	1.55	0.85	6	13
8	0.19	2.05	1.10	14	21
10	0.14	1.15	1.10		
15 CrNi 6	0.15	1.55	1.55		
18 CrNi 8	0.18	1.95	1.95		

It will be noted in Fig. 1 that steel 8-B lies slightly above the hardenability band for standard boron-free 18 Cr Ni 8, with the same chromium but about twice the nickel. Boron in this event could save perhaps 15 lb. of nickel per ton, with no change in chemical analysis of the steel otherwise.

Steels 10 and 15 Cr Ni 6 are representative of the low-carbon carburizing steels and their hardenability is less than the above when fortified with boron. Even in these low-carbon steels boron is fortunately of advantage. Curves published in the German literature indicate that up to 10 sixteenths from the quenched end, steel 10-B is a little softer than 15 Cr Ni 6, but beyond that its hardness falls off rapidly. The alloy content which can be replaced with boron, consequently, is less than the sum of 8 lb. chromium and 9 lb. nickel per ton.

Heat Treatability of the Carburizing Steels– In order to investigate the effect of the boron addition on the steel's behavior upon heat treating, the properties of the case and the mechanical properties of the core, specimens 1 in. in diameter and 3 in. long were carburized at 1615 and 1740° F. for 2 and 6 hr. at each temperature in a mixture of 60 parts charcoal and 40 parts barium carbonate. Specimens were quenched in oil from the carburizing temperature and hardened a second time at 1500° F. in a salt bath followed by an oil quench.

Neither the case depth nor the surface hardness appeared to be clearly influenced by the boron content. Carbon content of the case, analyzed from 0.1-mm. layers on different specimens, was identical for boron-free and boron-treated specimens. Neither were there any differences in hardness distribution on taper-ground sections through the case.

The frequent references in foreign literature to the grain-coarsening effect of boron could not be verified. All our steels had a grain size of about 8 in the McQuaid-Ehn test. Also, the fracture grain of the core was fine after double hardening; in this respect, the boron steels were far superior to the other steels tested. (It may be arguable whether the deoxidation and denitriding with ferrotitanium were influential in this respect.)

Warpage – A few tests were made in a laboratory heat (650-lb. electric furnace) of 0.13% C, 1.55 Cr, 0.91 Ni and 0.009 B and a 30-ton electric heat with 0.14% C, 1.56 Cr and 1.50 Ni. The test piece was a ring 4¾ in. o.d., ¾ in. thick, with 1.57-in. bore.

This established evidence that the greatest differences resulted from direct quenching from the carburizing temperature. The boron-treated steel warped more than did the boron-free steel, and exhibited an especially pronounced shrinkage of the bore.

Tensile strength was computed from Brinell hardness of samples subjected to the "blind hardening test", wherein slices 5, 10, 25 and 50 mm. thick (0.20, 0.39, 0.98 and 1.97 in. thick) were cut from a 2¾-in. square bar. These were normalized at 1600° F. and hardened from 1525° F in oil.

Tensile strength equivalents of hardness of

Table II – Data Concerning Nickel-Free Through Hardening Steels

Mark	Chemical Composition*						Heat Treatment	
	C	Si	Mn	Cr	Mo	V	Normalize	Harden
13	0.37	1.42	1.50	*a*	*a*		1725	1635
14	0.37	1.31	1.22	*a*	*a*		1725	1635
37 MnSi 5	0.37	1.25	1.25					
15	0.35	0.34	0.77	1.17	*a*		1625	1535
16	0.34	0.28	0.89	1.15	*a*		1600	1510
17	0.36	0.33	0.60	1.66	*a*		1600	1510
34 Cr 4	0.34	0.25	0.65	1.05				
18	0.35	0.28	0.61	1.12	0.28		1610	1515
19	0.40	0.25	0.58	0.94	0.10		1610	1515
34 CrMo 4	0.34	0.25	0.65	1.05	0.20			
20	0.44	0.30	0.78	*a*	1.69	0.12	1635	1545
21	0.44	0.26	0.66	*a*	1.05	0.07	1635	1545
22	0.46	0.34	0.83	*a*	1.13	0.11	1615	1525
23	0.52	0.29	0.90	*a*	0.79	0.07	1615	1525

*Boron-treated portions of heats were treated with titanium, and analyses showed 0.03 to 0.10% Ti, 0.0021 to 0.0041 B, and 0.002 to 0.008% N_2. Untreated steels analyzed 0.006 to 0.014% N_2.

a means that the element existed only incidental to the purity of the melting stock. Chromium varied from 0.03 to 0.08%, molybdenum from 0.03 to 0.08%, and nickel from 0.03 to 0.06%.

Boron Saves Nickel and Chromium

representative steels with and without boron are given in Fig. 2, where the higher-carbon alloys No. 4, 5 and 8 are shown at the left and the lower-carbon No. 10 and 15 Cr Ni 6 are at the right. Improvement in hardenability by this test is also clearly shown.

Notched bar impact specimens 1.06 in. (27 mm.) in diameter were cut longitudinally from the core of pieces subjected to the heat treatment described above. Tensile strength in psi. was computed from hardness. Impact strengths are in kg-m. per sq. cm. Averages for 8 samples are as follows:

Mark	No Boron		Boron	
	Strength	Impact	Strength	Impact
4	157,000	4.9	167,000	6.3
5	170,000	6.8	180,000	7.6
8	200,000	8.4	212,000	7.9
10	142,000	10.3	145,000	14.3
15 Cr Ni 6	157,500	14.3	165,000	14.8

Disregarding steels No. 8 and 8-B with 0.19% C, 2.05% Cr and 1.10% Ni, the boron addition has increased both the impact and the tensile strength somewhat, thereby improving the quality. The improvement would essentially seem to be the immediate result of the increased proportion of martensite phase existing in the microstructure.

On the basis of the hardenability tests it was anticipated that the boron-treated steel 10-B, lean in alloy (Table 1), would fail to attain the quality level of standard steel 15 Cr Ni 6 with the higher chromium and nickel. Hence, disregarding possible simultaneous reduction of chromium and nickel which may be justified by investigations now in progress, and giving preference to the urgent necessity of saving nickel, the nickel in the standard steel was cut in half, giving steel No. 5 with 1.55 Cr and 0.85 Ni. Figure 2 shows that this steel, 5-B, has excellent hardenability in the blind hardening test. Its impact strength is also reasonably good. These conclusions have been verified in commercial production in 30-ton arc furnaces.

The boron in steel 4-B, however, in spite of the low chromium and nickel contents of 1.15 and 0.58% respectively, has rendered it comparable to the boron-free steel No. 5, containing about 0.40% more chromium and 0.30% more nickel. Consequently, the possibility of saving some 13 lb. of alloy per ton of steel is at hand. The boron addition to steel No. 5 has, to be sure, increased its hardenability almost to the level of boron-free steel No. 8, in spite of being about 0.50 lower in chromium and 0.30 lower in nickel. However, the tensile and impact have not been improved.

Consequently, an alloy saving of about 16 lb. per ton, which would be indicated from the standpoint of hardenability, cannot be entirely

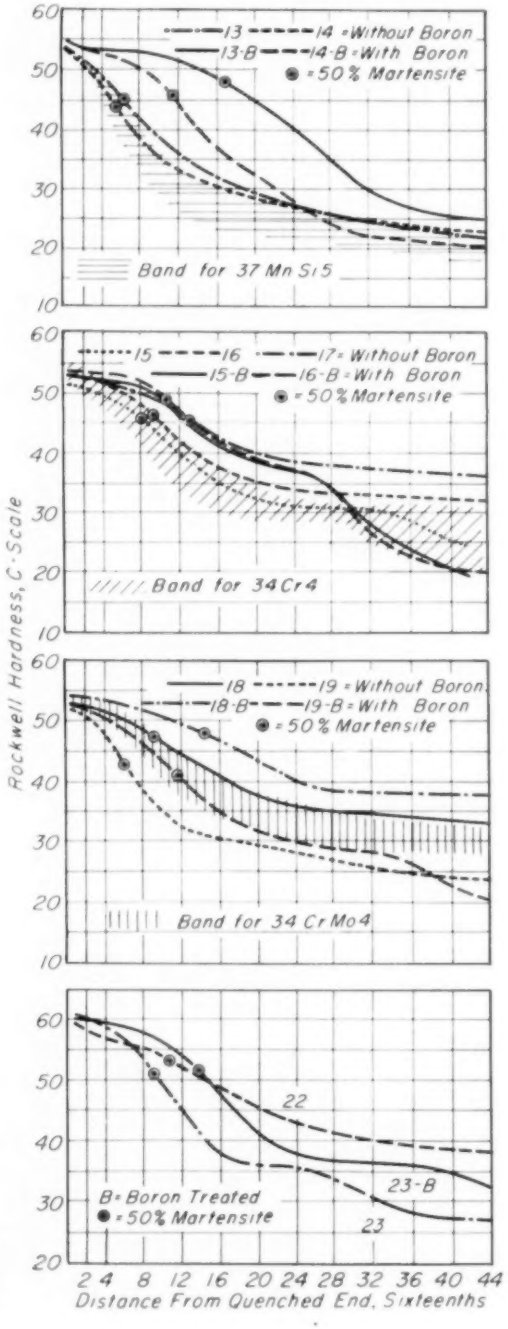

13 14 = Without Boron
13-B 14-B = With Boron
● = 50% Martensite
Band for 37 Mn Si 5
15 16 17 = Without Boron
15-B 16-B = With Boron
● = 50% Martensite
Band for 34 Cr 4
18 19 = Without Boron
18-B 19-B = With Boron
● = 50% Martensite
Band for 34 Cr Mo 4
22
23-B
23
B = Boron Treated
● = 50% Martensite
Rockwell Hardness, C-Scale
Distance From Quenched End, Sixteenths

Fig. 3 — Hardenability of Boron-Free and Boron-Treated Steels (Experimental) Compared With Hardenability Bands of German Standard Steels, Nickel-Free, for Through Hardened Parts

achieved in practice because parts made from such a steel could not be loaded to a corresponding degree in service.

Summary—Boron increases the hardenability, depending on the kind and balance of the alloying elements and may amount to the equivalent of 14 lb. chromium plus nickel per ton of steel. The industrial possibilities of saving nickel can only be evaluated after service testing of a boron-treated chromium-nickel case hardening steel containing about 1.55% Cr and 0.80% Ni, replacing the standard 15 Cr Ni 6 steel with 1.55% Cr and 1.55% Ni. It should be pointed out that German standard steels contain no molybdenum and there is therefore no possibility of saving molybdenum by boron additions.

THROUGH HARDENING STEELS

As in the studies outlined above, a dozen or more experimental heats of alloy steels designed for through hardened parts were made, each heat being split and the second part treated with titanium and boron. For a base of reference, parallel tests on the much-used German standard steels 37 Mn Si 5, 34 Cr 4, and 34 Cr Mo 4 were made. Again, the reader can refer to the German literature for full documentation; at this time only representative data can be discussed. Analyses of these steels are given in Table II on p. 73.

No steels containing significant amounts of nickel were included. Those German steels for heat treating, based on the chromium-molybdenum-nickel combination, are used only for structural elements of large cross section exposed to maximum stress where deep and uniform response to heat treatment is a requisite. Furthermore, since only about 7% of the total German production of alloyed heat treating steels is based on nickel as an alloying element, it would seem that the substitution of boron for nickel in this class of steels produced in Germany does not promise any possibilities of useful savings.

End-quench hardenability curves of these steels, with and without boron, are given in Fig. 3, wherein the points corresponding to a structure of 50% martensite are also indicated. For comparison, the scatter bands established on a number of production heats of comparable standard steels are indicated by cross hatching. Depth of hardening was improved for all the steels by the addition of boron. This effect is especially noticeable for the steels intrinsically shallow hardening – the silico-manganese steels No. 13 and 14 and the chromium-molybdenum steel No. 19. As would be expected, the effect of boron is slight on the high molybdenum-vanadium steel 20-B (not shown) which is deep hardening anyway.

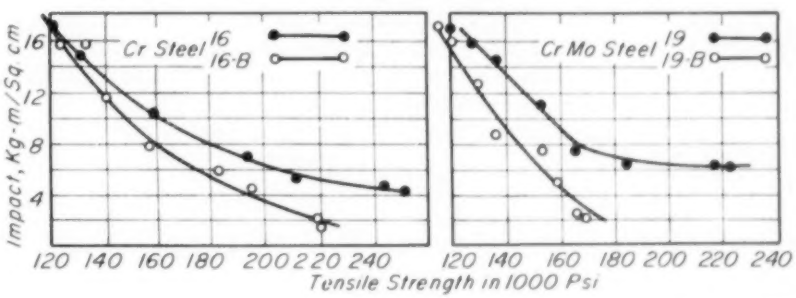
Tensile and Impact Properties

Tensile properties of the steels were studied by pulling test pieces about 1 in. diameter (28 mm.) after normalizing and oil hardening from the temperatures shown in Table II and then drawing back to 350 to 650° C. (660 to 1200° F.) in increments of 50° C. (90° F.), and finally quenching in oil.

Generally speaking, the advantage of higher ultimate strength of the boron-treated homologue (amounting usually to about 14,000 psi. at the 660° F. draw and about half as much after the 930° F. draw) disappears after higher tempering temperatures. The same thing may be said of the yield strengths, so that the ratio of ultimate to yield is about constant after all temperatures of draw. Influence on ductility is minor or indecisive – especially in the range of draw temperatures used in industry. Boron has very little influence on the percentage elongation at fracture of any of the steels. It materially improves the reduction of area, after low draws, of chromium steel No. 16 but depresses it in the higher chromium steel No. 17.

Impact strength of normalized and hardened steels was investigated after various draws, wherein some test bars were oil quenched from the draw and others (to investigate "temper brittleness") were cooled in the furnace. Space does not permit the presentation of the volumi-

Fig. 4 – Toughness (Notched-Bar Impact) Plotted Against Tensile Strength of Chromium Steel No. 16 (Left) and Chromium-Molybdenum Steel No. 19 (Right). Boron did not much affect this relationship in the other steels tested; in these two, boron improved the toughness at high strength to a notable degree



nous results, but perhaps some generalizations may be permitted.

Considering the scatter attendant to notched-bar impact tests, it may be said that toughness of some boron-treated steels is somewhat better, yet for others slightly worse than that of the boron-free steels of otherwise similar composition. There is no clearly recognizable relationship to the alloy type, yet there exists a certain superiority of the boron-treated steels among those of lower hardenability. Tendency toward temper brittleness is increased by boron in the manganese-silicon steels, but this does not exist in the other varieties – at least under the selected experimental conditions. The data for the manganese-silicon steels No. 13 and 13-B, in terms of impact energy (kg-m. per sq.cm.) are as follows:

Draw Temperature	Oil Quench		Furnace Cool	
	No. 13	13-B	No. 13	13-B
450° C. (840° F.)	5.5	5.0	4.6	4.1
500° C. (930° F.)	5.8	5.2	4.2	2.9
550° C. (1020° F.)	6.0	5.1	4.7	2.7
600° C. (1110° F.)	8.6	8.6	4.7	3.7
650° C. (1200° F.)	12.3	11.5	5.5	4.5

When notched-bar impact strength after various temperings is plotted against tensile strength after identical heat treatment, the curve for a boron-treated steel almost superimposes on that for the boron-free variety although it seems that for the steels with higher hardenability the boron steels are a little less tough after the higher draws. This statement applies to the silicomanganese steel, the chromium-vanadium steels, and one chromium-molybdenum steel No. 18. Circumstances for the chromium steel No. 16 and the chromium-molybdenum steel No. 19 are shown in Fig. 4. A study of the tensile properties of a 30-ton electric furnace production heat of boron-treated steel of basic composition 0.41% C, 1.0% Cr corroborated these results, although the impact values are not so much higher than expected in a boron-free steel, possibly because of the greater reduction from ingot to finished bar of the material in production.

Our investigations also verified the fact that a boron addition improves the depth of hardening in steels with a naturally low penetration of hardness, and that a boron addition does not impair the impact resistance of the core of a large, heat treated part – in fact, it is improved in 2¼-in. square bars of steels of low hardenability. One exception is the boron-treated silicomanganese steel 13-B; this exception is yet to be completely explained.

Except for molybdenum-vanadium steel No. 20, all the boron-free steels we studied were less hardenable than the boron-treated steels, irrespective of alloy composition. Nevertheless, they are not interchangeable with an arbitrarily chosen boron-treated analysis, since the latter exhibits no general superiority in the tensile tests. In all instances the characteristic effect of individual alloying elements affects the performance. For example, the boron-treated silicomanganese steels distinguish themselves clearly from the boron-free chromium steels by their inferior toughness when heat treated to equal hardness and strength. For example:

	Si-Mn, No. 13-B	Cr, No. 16
Ultimate strength	170,000 psi.	170,000
Yield strength	155,000	160,000
Reduction of area	41%	47%
Elongation in 5 dia.	13%	10%
Notched-bar impact	5.0 kg-m.	6.5 kg-m.

In one more favorable comparison, the boron-free steel No. 17, with 0.36% C, 1.66 Cr and 0.04% incidental Mo, and the boron-treated steel 19-B with 0.40% C, 0.94 Cr and 0.10 Mo have similar hardenability and ductility but a little higher yield strength ratio at the higher impact values. The somewhat higher molybdenum content of 19-B would hardly influence the matter and the conclusion may be drawn that, with the sections studied, the possibility presents itself to save about 14 lb. of chromium per ton of steel.

Considering now a somewhat richer steel than 19-B, namely steel No. 18 with 18 points more chromium and 18 points more molybdenum, we find that tensile properties are about equivalent at all tempers. The notched-bar impact strength of the boron steel 19-B is lower at lower strength levels (higher draws) but this relation changes at higher strength (lower draws). To save molybdenum by substituting 19-B for 18, therefore, the boron-treated steel should be used at higher temperatures – that is, after drawing at lower temperatures.

In the practically useful tensile strength region, the experimentally determined tensile properties of the boron-free molybdenum-vanadium steel No. 22 differ but little from those of the boron-treated steel 23-B which contains 34 points less molybdenum and about half the vanadium. The notched-bar impact strength of 23-B is somewhat lower than that of the more highly alloyed boron-free steel. Such a substitution would save about 7 lb. of alloy per ton.

Lastly, it appears that about 50 points of chromium (10 lb. per ton) could be saved by substituting 15-B or 16-B for steel No. 17. Their

(*Continued on page* 174)

The Road Ahead*

By THOMAS E. MURRAY, Commissioner
U. S. Atomic Energy Commission

ALTHOUGH THE FUTURE seldom turns out quite as one expects, I think it safe to say, at the outset, that our world for some time to come will be on a walk through a "valley of the shadow of death". The first business of this generation is to see to the survival of science and philosophy—yes, even of all of civilization.

This matter of survival has been especially on my mind since a year ago when I participated in our thermonuclear testing in the far Pacific. Had you been with me last fall at our testing station at Eniwetok, you would have no doubt that mankind now has within the range of its grasp means to exterminate the human race. The Road Ahead then must be deliberately chosen as a road to survival. I am certain we are not on this road yet. We will have to make some hard, deliberate changes in our present direction in order to get squarely on this road.

Scientists have known for many years the theory that the fusion of light elements under certain conditions should release large quantities of energy, but during my early days on the Commission I heard from very knowledgeable scientists that it was probably impossible to bring about a thermonuclear explosion. Furthermore, there was no pressure to develop a device employing such a theory. We were comfortably ahead of the U.S.S.R. in fission weapons —why chase after a near impossible?

"Joe 1", however, changed all that. ("Joe 1" is what we call the Russian test that we detected in 1949.) Stung out of our complacency by the unexpected speed of the U.S.S.R. atomic development, Commissioner Strauss proposed a "quantum jump" in our planning—to attempt the nearly impossible, the so-called hydrogen bomb. This proposal carried the day and the detonation of a fusion device November last permitted the Free World to save perhaps a small time margin over the Soviet program.

But the years of the atomic age race swiftly by. "Fusion Joe" (to give the recent Soviet test a shorthand name) is now history—ugly, unwanted, Fusion Joe—proving again that science is universal.

And now the times cry out urgently for another "quantum jump", not in technology, but in world politics. There is still some reason for hope. Is it out of all reason to at least speculate on the possibility that two nations which combined to fight against Hitlerism could not find some common ground on which to stand together against the immeasurably greater menace of general atomic war?

I have not too much trouble in believing that if this planet were infested with a universal plague or with a hostile force from space, common ground might be found to permit a common defense of our world. Well, a plague is here, a force is here that can destroy us all, and such inevitable destruction of civilization means death to Sovietism as well as to Democracy. The United States must get this cold realization first and this should give the Kremlin cause to reconsider. The promise of Marx was eventual *triumph* for Communism—not *extinction* together with Capitalism in a man-made abomination of desolation.

But, let me remind you that The Road Ahead is a toll road. It will take its toll of some of our cherished national illusions, one of which is a belief in the natural superiority of any product, intellectual as well as material, which bears the label "Made in the USA". The road to survival will require immense expenditures of human energy in channels and in ways that we are not used to—and so, at first, will be quite painful. I have in mind the supernatural virtue that will be called upon to be patient for year after year of provocation and Soviet beast-like stalking of its prey.

Another toll that we shall have to pay, on The Road to Survival, is to abandon our practice of walking alone. To slow down the U.S.S.R.'s weapons program, we have tried to prevent the export of "classified" information. But events in the U.S.S.R., which it was designed to defer or prevent, have occurred and therefore this policy, it seems to me, needs modification. In football when the other team knows your signals, it is senseless to maintain the pretense of secrecy.

As a matter of fact, we have failed to preserve safety in exclusiveness. A new attempt should be made to work more closely with our original wartime atomic partners—the United Kingdom and Canada—and then with other friendly nations. This would be one step toward demonstrating to the world our belief that atomic energy as the great threat to man's survival is *everybody's* business.

Again—to my mind, first-hand experience with a mammoth atomic explosion is an essential qualification for future negotiators of the great survival issues in the years ahead. To this end we might consider the policy of more extensive observation of large-scale atomic testing—including foreign observers—as we had some years ago at Bikini. I believe this could again be done without loss of security or disclosure of weapons technology.

It seems to me not beyond possibility that if such a step were taken by us, the Soviets might, in deference to world opinion, match it by opening up somewhat their future testing activity—a step that could have incalculable benefit in advancing the search for peace. In our Herculean efforts to make the Soviet see that their interest and ours lies in atomic weapons *control*, it will undoubtedly be necessary to take unusual measures. That is one of the tolls which is payable on The Road Ahead.

*Verbatim extracts from an address for the 75th anniversary of Duquesne University, Pittsburgh, Nov. 11, 1953. Publication of these extracts does not constitute an endorsement by the American Society for Metals.

Short Runs

Brazing

A NEW TECHNIQUE for brazing stainless steels in controlled atmosphere has been worked out by the General Electric Co. Ltd., London. The process, suitable for the brazing of stainless steels with copper and "Nicrobraz" alloy, maintains very close control of oxygen, carbon dioxide and water vapor of the furnace atmosphere. These cause the formation of an oxide film on the surface of the components that prevents the liquid brazing metal from alloying with the exposed surfaces so as to produce a sound joint.

The vertical cylindrical furnace with gas-tight container shown in Fig. 1 has given good results when used for the process. It has effective loading dimensions of 17 in. diameter by 58 in. deep and can be used for all brazing in the temperature range of 1300 to 2160° F. The method for its operation is as follows:

1. After loading the stainless steel assemblies on the support casting, the pot is sealed and immediately purged with the protective atmosphere of dry hydrogen. However, if desired, it may first be purged with nitrogen.

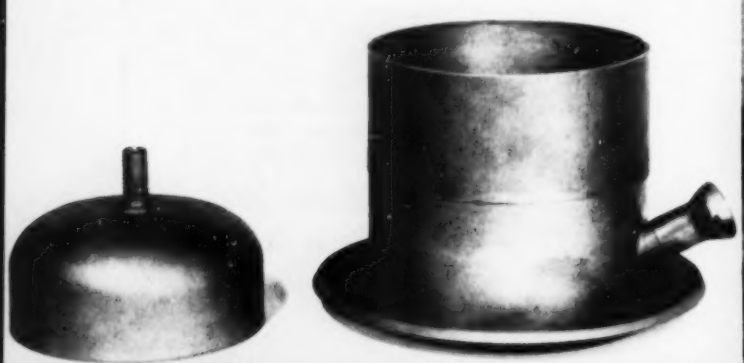
2. The pot is loaded into the furnace and the charge brought to the required temperature in the controlled atmosphere and held at that temperature for 10 to 30 min., depending upon the brazing alloy being used.

3. The pot is removed from the furnace and cooled under the protective atmosphere. The holding time at high temperature is short; for most filler metals 10 min. is sufficient but when Nicrobraz is used a suitable period has been found to be 30 min.

A component which has been joined by this Nicrobraz technique is shown in Fig. 2. For the unit on the left, a mild steel stud has been brazed into a nickel-alloy cup, and for the assembly on the right, joints have been made between the upper and lower cylinders and between the lower cylinder and the spout. Parts for the latter component are of mild steel and nickel alloy. Nicrobraz was selected for the brazing alloy because of its resistance to corrosion. The principal application of the Nicrobraz alloy, however, is for service at elevated temperatures where the high strength and oxidation resistance of the joints are fully utilized.

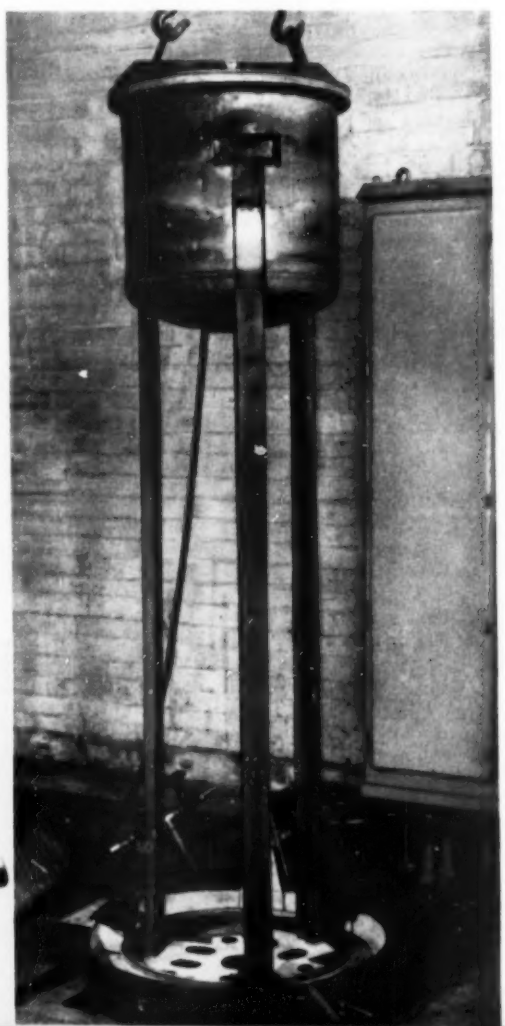
Fig. 1 – Furnace Assembly (Minus Air-Tight Pot) for Brazing of Stainless Steel Components

Fig. 2 – Components Brazed According to Special Technique Evolved by General Electric Co., Ltd., England



Furnace Insulation

THE USE OF boron nitride as a thermal and electrical insulation in furnaces for vacuum induction melting is reported by R. V. Gray, Knolls Atomic Power Laboratory, Schenectady,



N. Y. It is extremely difficult to maintain a good vacuum at high melting temperatures when graphite crucibles are used because a reaction between the crucible and the usual surrounding insulation such as corundum, zirconia, magnesia releases gas. This reaction can be avoided by using powdered graphite or carbon black; however, there are several disadvantages to the use of these materials. Hot spots may form and arcing occurs between the insulating material and the heating coil. Furthermore, these powders act as susceptors instead of as insulators; also they readily absorb gases, making it difficult to attain a high vacuum.

The use of boron nitride has been found to eliminate completely these problems associated with high-temperature melting in graphite crucibles. The material used was obtained from the Norton Co., Worcester, Mass., in a finely divided state with a particle size of approximately 2 microns. The crucible is rammed in the heating coil assembly surrounded by the boron nitride. A thin layer of alundum cement on top retains the insulating material. By insulating the graphite crucibles in this way, it has been possible to melt and cast zirconium and zirconium alloys at 3540° F.

Method for Revealing Hairline Cracks

THE PRESENCE of small hairline cracks in steel specimens, particularly in case hardened material, can be detected by an easily applied method. The specimen is first magnetized and then polished by hand on 0, 00, and 000 metallographic papers. When polishing is completed on the last paper, a final stroke is applied very lightly so as to scarcely touch the paper. The fragmentary material from the polishing on the last paper supplies the necessary magnetic powder.

Figure 3 is typical of the results obtained by this method of defining such cracks. This macrograph is of a specimen from a nitrided gear that failed in service by cracking and spalling. The gear had been magnetized for "Magnaflux" inspection several days previously and enough magnetism remained to give the results shown. The crack in the core and those in the case on the tooth face are very fine and are not visible at 12× when the powder outlining them is removed.

The term "magnapolish" is suggested as a possible name for this operation.

WELTON J. CROOK
School of Mineral Sciences
Stanford University

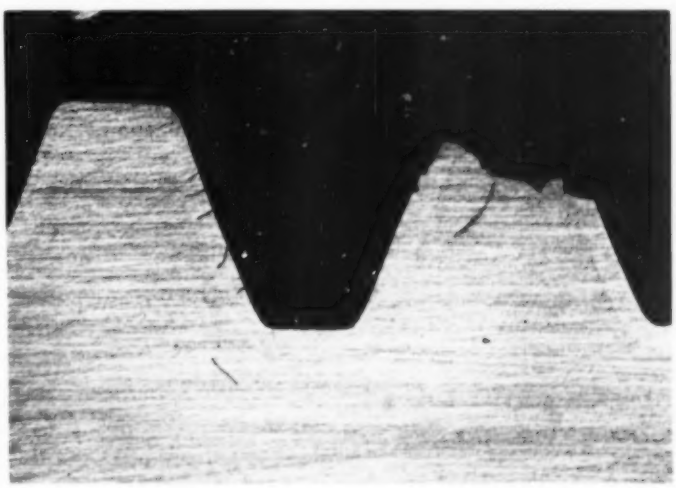


Fig. 3 – Hairline Cracks in Nitrided Gear Revealed by Magnetically Held Fragments Left by Last Polishing Operation. Unetched, 8×

1916 Production of Stainless in Norway

THE STATEMENT in John Sissener's article on "Norwegian Production of Stainless Steels" in the January issue of *Metal Progress* that Stavanger Electro-Staalverk A/S first made stainless steel in Norway in 1916 led the editor to ask Alf Pettersen, Stavanger's chief metallurgist, to look into the records for what might be a historical milestone. ("The Book of Stainless Steels" quotes J. H. G. Monypenny to the effect that *low-carbon* stainless steel with 12% chromium was first made on a commercial scale at Brown Bayley's Steel Works in Sheffield, England, in June 1920.)

Mr. Pettersen replies:

As far as I can find, the first time the high-chromium steel is mentioned in our old files is in a letter of Sept. 22, 1916, from Daniel Doncaster & Sons, Merchants and Manufacturers of Sheffield, England, wherein they ask for a steel to the following specification in ingots or 3-in. square billets: 0.20 to 0.25% carbon, 0.35 to 0.40% manganese, 14 to 15% chromium, 0.50 to 0.60% nickel.

Short Runs

The intended use of the material is not stated, but since the forge department of Doncaster signed the letter presumably it was to be forged there.

Our quotation for a lot of 3 to 3½ tons follows in a letter of Oct. 4, but was contingent on delivery of the necessary ferrochromium with low carbon from England.

There follows a lot of correspondence. One of the difficulties was due to what we then regarded as a rather low carbon content. Finally it was agreed to accept a rather higher carbon content. On Dec. 15 the steel was teemed with the following analysis:

Carbon	0.33%
Silicon	0.17
Manganese	0.40
Sulphur	0.014
Phosphorus	0.020
Chromium	14.09

Thus it conforms to the "original cutlery type" of stainless steel mentioned on p. 279 of "The Book of Stainless Steels", 1935 Edition.

It was cogged under the hammer to 3-in. square billets and was ready for dispatch in January 1917. In July the customer asked for more, for they were well satisfied with the first lot received.

The charge was melted in a 5-ton, tar-fired basic Siemens-Martin openhearth furnace. Tar was used because other suitable fuel could not be obtained during wartimes. After melting down and boiling, the steel was duplexed to a Röchling-Rodenhausen low-frequency furnace of the same capacity for further refining and alloying. The finished steel was then teemed into ½-ton ingot molds.

Mold Lubricant

ALL SORTS of problems can arise when a molten metal comes in contact with a mold, such as the "soldering" of aluminum to steel experienced by H. R. Engineering Laboratories, East Haddam, Conn., during the centrifugal casting of squirrel-cage rotors used in electric motors. The obvious answer was to use a mold coating, but which one would do the job took some finding out.

The problem was solved with the use of a dispersion of colloidal graphite in water (known commercially as "Aquadag") which could be applied to the molds by spraying, painting or dip coating. It forms a dry lubricating film on the surface of the mold.

Details of the mold-coating procedure, as recommended by the lubricant manufacturer, are as follows:

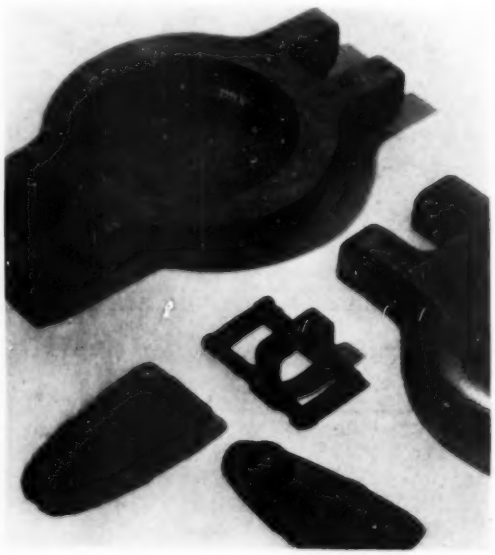
Use a mixture of 1½ to 2 oz. "Aquadag" per gal. of water.

Apply the lubricant to the top of the hot mold either by spraying or painting, or by dipping it into the solution and withdrawing quickly to permit the water to evaporate.

This procedure not only coats and lubricates the mold, but also cools it so additional cooling is not necessary except on larger size molds. It is stated that this material was found to be "the most convenient to apply, the most adhesive and generally most satisfactory".

Castings

TITANIUM castings of good quality are being made by National Research Corp., Cambridge, Mass., as a result of the discovery of a mold material that withstands attack by the molten metal. These parts, weighing up to several pounds, were produced in a vacuum arc furnace to control oxygen, nitrogen and carbon to limits comparable with those for wrought titanium. Surface smoothness is equal to that of good sand castings. Pilot quantities of pure and alloyed titanium castings are being made for the U. S. Army Ordnance Corps at Watertown Arsenal. Some typical examples are shown in the photograph below.



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- *High-Quality Material for Every Need*—ELECTROMET ferrovanadium is uniform in analysis, closely graded, correctly sized, and physically clean. It is furnished in these grades:

	Vanadium	Silicon max.	Carbon max.
High-Speed Grade	50 to 55% or 70 to 75%	1.50%	0.20%
Special Grade	50 to 55% or 70 to 75%	2%	0.50%
Open-Hearth Grade	50 to 55%	8%	3%
Foundry Grade	50 to 55%	approx. 10%	3%

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Sharpness Tester for Razor Blade

KYOTO, JAPAN

THE MOST common sharpness tester of cutlery in Japan is the instrument designed by Kotaro Honda which was described in *Metal Progress* for March 1931. In Honda's paper-cutting tester, a narrow band composed of strips of paper is held under a definite pressure across the blade edge and is moved back and forth over the edge in a direction parallel with its length. Honda's tester, which is very simple to manipulate, measures the durability of the edge. It is not adequate, however, for measuring sharpness because the mechanism of the paper-cutting tester employs the "hacksaw effect"—an action never used in shaving.

The writer and his associate Takao Kawakita devised the string-cutting sharpness tester for razor blades shown in the photograph and sketch. This instrument consists of glass reservoirs A and B which are connected by a rubber tube, buoy C which floats on the water in A, and the beam D on which C is hung. String E, held by clip G, is spun on slit F by means of clip H to which a small plumb bob is attached; the blade is fixed to plate J as shown in the diagram. As the reservoir B is lowered, the water level in A drops and C becomes exposed. This results in a decrease of the buoyancy of C, the load on D increases and the string E is cut by the blade. The load to cut the string is obtained by reading the water level indicated by the scale marked on the buoy C. The sharper the razor blade is, the smaller the cutting force will be.

In a single blade every point along the edge shows different sharpness. The distribution of the sharpness in one blade differs with the maker of the blade. Actual shaving showed that in the good blade the mean value of the cutting force is small while the deviation in the distribution diagram (cutting force-frequency) is small too.

Fig. 1 – String-Cutting Sharpness Tester for Razor Blades

The writer tested various razor blades on sale in Japan. The results are as follows:

TRADE MARK		CUTTING FORCE
American		76
J. A. Henckels	(Germany)	48
Rockman	(")	66
Globusmann	(")	73
Punktal	(")	58
Feather	(Japan)	40
Citizen	(")	34
Proton	(")	44
Sarjin	(")	26
Christel	(")	26

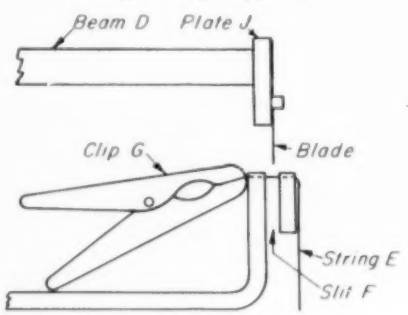
Cutting force means the force in grams required to cut the cotton string. The measurements were made at 13 points along each edge and the mean value of the cutting force was calculated from two edges.

The sharpness of a razor blade generally degenerates as time elapses. At the time the blades for testing were bought at retail, those of Japanese make were "fresh" while foreign ones were "aged". If fresh American and German blades are tested, these cutting forces may be smaller than those reported.

If a human hair is used instead of the string, one can determine the force required to cut it, and the pulling force in shaving can be approximated. The writer experimented with tensions on hairs to determine the resulting sensation. It was found that if a hair is pulled by a

(*Continued on p.* 114)

Fig. 2 – Detail Sketch of String-Cutting Apparatus



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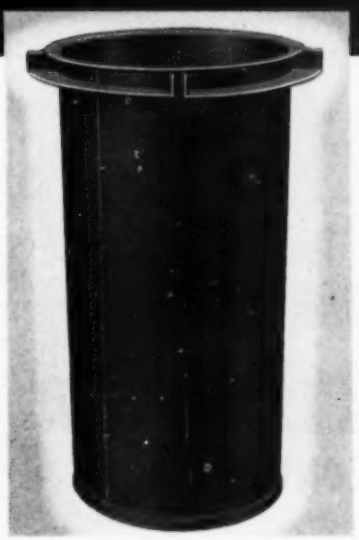
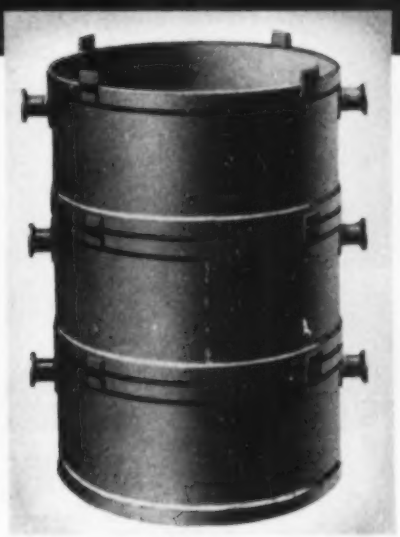
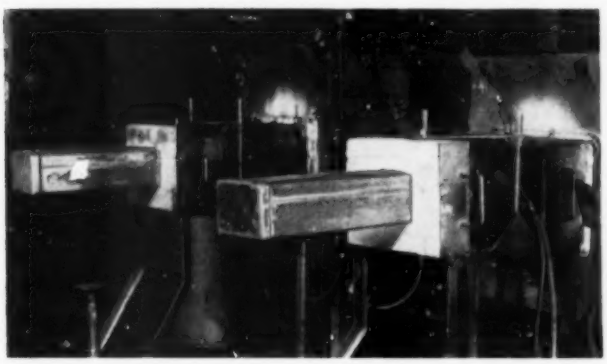


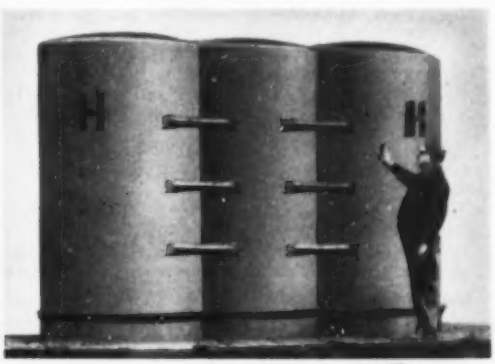
Retort has fabricated grid-type bottom. Light weight saves handling and heat-up time.



Retort for small lots of different parts -- one of many special-purpose PSC heat-treat units.



Above, retorts for 2150°F. At right, light-weight hoods; handle easily. PSC fabricates complete list of ferrous and non-ferrous metals, alloys.



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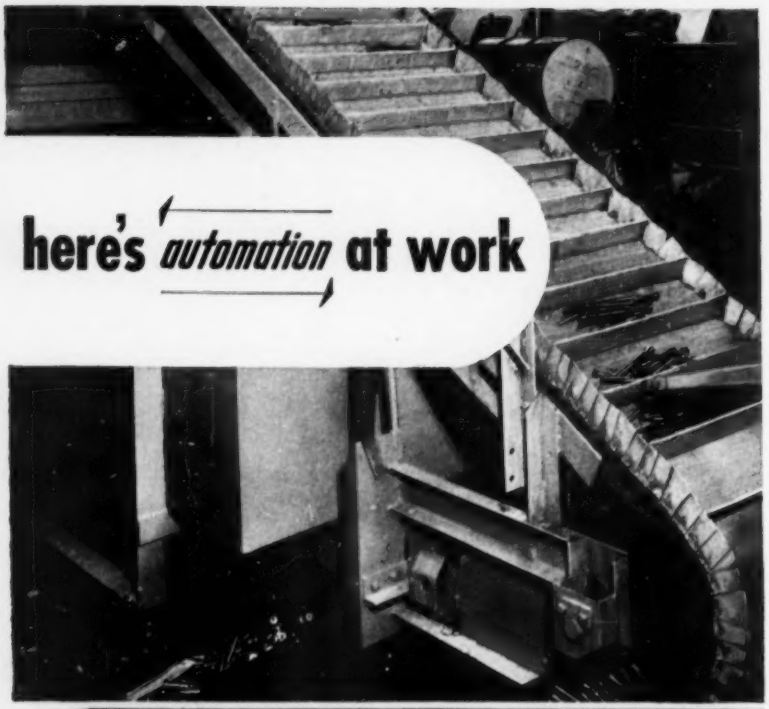

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Correspondence

(*Cont. from p.* 112) force less than about 15 g., no pain is felt. If good blades, such as the ones requiring a cutting force for cotton string of 25 to 35 g., are applied on the moist hairs in shaving, they do not "pull" more than 10 g. Such shaving gives a very comfortable touch.

This tester is very simple and rapid to operate. The load increase is continuous, shockless and automatic. It can measure the sharpness of the blade at any point. The measurement is nondestructive to the edge.

KEIZO IWASE
President
Japan Institute of Metals

Open-Circuit Couples

PERIVALE, ENGLAND

We read with interest the article "The Open-Circuit Thermocouple" in the November 1953 issue.

In the tin-plate laboratories of the Tin Research Institute a similar technique is in regular use for measurement of the rate of heating of strip specimens about 0.010 in. thick by 0.5 in. wide. Very fine (0.0076 in.) iron-constantan thermocouple wires are spot welded in the required position on a face of the specimen, and connected by a cold junction to a 0.1-sec. period galvanometer. For calibration purposes a small piece of the specimen is later cut up and calibrated against a substandard mercury thermometer in a small specially designed furnace.

In a particular example, galvanometer readings were taken at short time intervals during the heating of steel specimens measuring 0.01x0.5x4 in. and having 20-cu.mm. pellets of solder on the circuit. At a heating rate of about 10° C. (18° F.) per sec. the eutectic and liquidus temperatures of the solder are easily and accurately measured.

In other studies (to be published later) rates of heating of 130° C. (234° F.) per sec. have been followed. In these no significant constitutional changes were involved.

We may say that the actual welding operation using such fine-gage wire is a most delicate job and required the design of a special jig.

C. J. THWAITES
Tin Research Institute

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Personal Mention

Robert Scherer

Professor Scherer, principal author of the article on "German Investigations on Boron Steels," p. 101 of this issue, was educated at the Aachen Institute of Technology, and has received not only the engineers' and doctors' diploma but can sign himself Dr.-Ing-Habil, which highest degree was conferred upon him in 1943. After graduation, he started working for the Becker Steelworks in Willich and became director of research for the Deutsche Edelstahlwerke A. G. in Krefeld in 1932. Since 1948 he has been a director of the firm and chief executive of all technical activities. He has held a lectureship in the Technical Institutes of Hannover and of Aachen for many years, and in 1953 was named a full professor. He has contributed generously to the German literature on engineering alloy steels, toolsteels, and stainless steel.

Karl Bungardt

Dr. Bungardt, co-author of the article on German boron steels, is also an alumnus of Aachen Institute of Technology (1934) and was a member of its faculty while studying for his doctorate. He joined the Aeronautical Research Institute in Berlin as superintendent of the light metal department. From 1938 to 1949 he directed the work on stainless and heat resisting steels at the Krupp works in Essen, and since then has been head of the Research Institute at Deutsche Edelstahlwerke A. G., in Krefeld.

Harry P. Troendly has been elected president of the spring division of Borg-Warner Corp., Chicago. Mr. Troendly was vice-president and general manager of the spring division since its founding 13 years ago.

Samuel Storchheim has been promoted from senior engineer to engineer in charge at the Atomic Energy Division of Sylvania Electric Products Corp., Bayside, N. Y.

Veryl W. Graze has returned to the metallurgical department of the central district of Republic Steel Corp., Massillon, Ohio, after having been on an extended leave of absence to assume the duties of acting chief, Metallurgical and Conservation Branch of the National Production Authority, Washington, D. C.

E. Clarke Quackenbush recently joined Whitney Blake Co., New Haven, Conn., as manager of the newly formed electronics division. Mr. Quackenbush has been continuously associated with the design and development of electric connectors since 1925, and prior to his present appointment was engineer in charge of the eastern division of Cannon Electric Co., Los Angeles.

Clyde E. Roberts was appointed manager of sales for Republic Steel Corp.'s alloy steel division succeeding **Martin H. Schmid**, who is retiring after 44 years service with Republic and predecessor companies. Mr. Roberts moves up from assistant manager and will continue to make his headquarters at Massillon, Ohio. Mr. Schmid is a graduate of Lehigh University, and in 1909 joined a Republic predecessor company, United Steel Co., at Canton, Ohio, as a member of the mechanical department. He became a metallurgical engineer in 1916. In 1924 Mr. Schmid was named assistant sales manager of United Alloy Steel Corp., another Republic predecessor company, and in 1936 he was appointed manager of sales of Republic's alloy steel division.

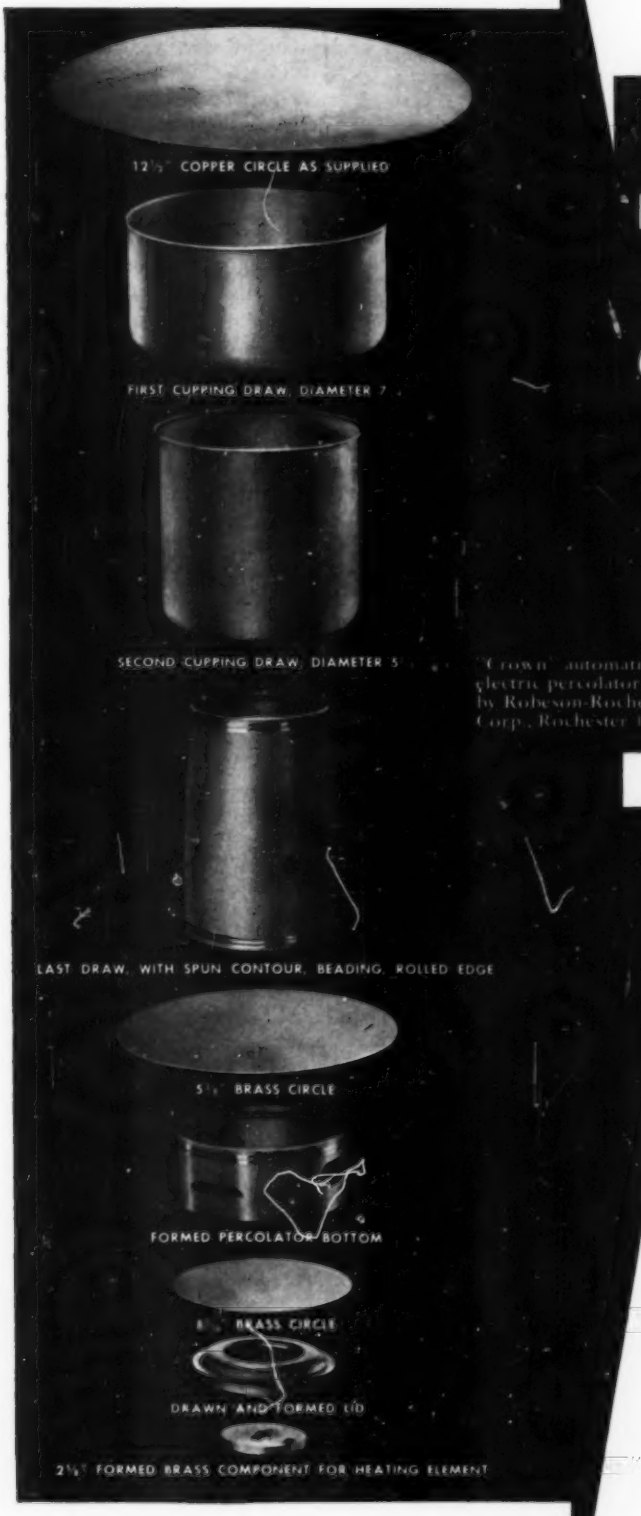
Joseph J. Moore, formerly sales representative covering the northern Ohio territory for G. O. Carlson, Inc., has been appointed manager of stainless steel sales for Viking Steel Co., Cleveland.

John M. Manypenny, formerly sales manager with Harshaw Chemical Co.'s scientific division, Cleveland, has been named eastern district manager for Beckman Instruments, Inc., South Pasadena, Calif., with headquarters at the company's new branch plant in Mountainside, N. J.

Norman K. Pettigrew, after 26 years with C. I. Hayes, Inc., of Providence, R. I., furnace manufacturers, during which time he rose from a beginning job as mechanic to a final position of vice-president, has resigned to organize his own company (Associated Designers and Builders of Providence, R. I.) and to engage in consultation practice on electric heat treating furnaces.

H. R. Lewis, chief metallurgist for Ohio Seamless Tube Division of Copperweld Steel Co., has culminated 45 successful years with the steel industry. He had been associated with the Ohio Seamless Tube Co. since April, 1919.

W. H. C. Berg has been appointed director of standards and research for the Hanson-Whitney Div. of Whitney Chain Co., Hartford, Conn.


12⅛" COPPER CIRCLE AS SUPPLIED
FIRST CUPPING DRAW, DIAMETER 7"
SECOND CUPPING DRAW, DIAMETER 5"
LAST DRAW, WITH SPUN CONTOUR, BEADING, ROLLED EDGE
5⅛" BRASS CIRCLE
FORMED PERCOLATOR BOTTOM
BRASS CIRCLE
DRAWN AND FORMED LID
2⅛" FORMED BRASS COMPONENT FOR HEATING ELEMENT

"Crown" automatic electric percolator, made by Robeson-Rochester Corp., Rochester 1, N.Y.

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Personals

Donald R. Guthrie is now assistant general manufacturing agent of the coated abrasives and related products division of Minnesota Mining & Mfg. Co. Mr. Guthrie formerly was executive engineer in charge of engineering research.

Rudolph Buechting has been elected vice-president in charge of plant operations of the Philadelphia Steel and Wire Corp., Philadelphia.

Raghunath C. Deshpande has accepted a position on the staff of the department of metallurgy of the Indian Institute of Science in Bangalore, India. Dr. Deshpande is a graduate of Rensselaer Polytechnic Institute, and returned to India to assume duties at the Delhi Polytechnic Institute in February, 1952, a position he held until his present assignment.

William A. Ross has been appointed sales manager of the Circo Equipment Co., Clark, N. J.

Willson V. Bliss is now a welding engineer for the American Locomotive Co. in Dunkirk, N. Y.

Howard D. Hodge, formerly metallurgist with the Titan Metal Mfg. Co., Bellefonte, Pa., is now a senior metallurgist in the metallurgical division of the Curtiss-Wright Corp., at Wood-Ridge, N. J.

Sidney F. Kaufman, a graduate from General Electric Co.'s chemical and metallurgical training program, has joined the Carboloy Dept. of General Electric Co. as an engineer in the carbide powder processing and fabrication development unit. He is a graduate metallurgical engineer from Carnegie Institute of Technology.

Harry D. Stephen, chief metallurgist for General Motors Corp.'s New Departure Division, Bristol, Conn., has retired after 35 years of service in the metallurgical department of the company.

S. L. Weaver has been appointed district sales manager of the Pittsburgh office of the Latrobe Steel Co., Latrobe, Pa. Mr. Weaver was formerly a sales representative for Latrobe in the Chicago territory.

R. W. Sandelin has been appointed technical director of the Alloy Metal Wire Co., a division of H. K. Porter Co., Inc., Prospect Park, Pa. Prior to his change in status, Dr. Sandelin was chief metallurgist with the Porter Co.'s Connors Steel Division. In his present position, he will head the metallurgical department and be responsible for quality control.

John T. Richards, formerly with the Beryllium Corp., Reading, Pa., was recently named president and chief engineer of Penn Precision Products, Inc., also in Reading.

Charles M. Ruprecht has been appointed president of the Electro-Alloys Division of the American Brake Shoe Co., located in Elyria, Ohio. Mr. Ruprecht was formerly vice-president of the division, and has been with the American Brake Shoe Co. since 1946.

Harold G. Williams, consulting metallurgist specializing in beryllium copper, is now representing Penn Precision Products, Inc., of Reading, Pa., in Metropolitan New York.

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"ALWAYS ON DUTY"
DIAMOND BLOCK
ELECTRIC FURNACES FOR H.S.S.* hardening

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Heat Treat 300 Header Tools Daily

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Special STRUCK SLOT hammer, a special item that gets the special heat treatment it deserves.

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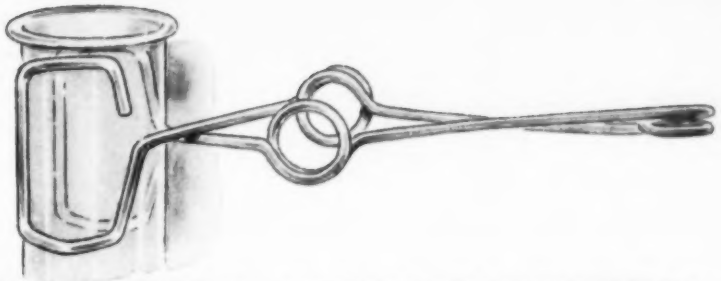

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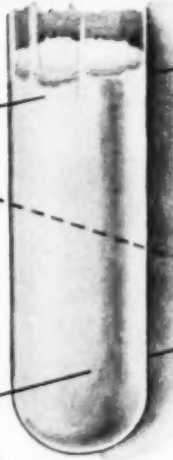

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MANUFACTURERS OF ZIRCONIUM COMPOUNDS

Personals

John C. Parry, formerly with the Baldwin Duckworth Div. of the Chain Belt Co., Springfield, Mass., is now assistant to the sales manager at Waldes Kohinoor, Inc., Long Island City, N. Y.

Robert K. Beck has been elected president of the Apex Smelting Co., Chicago. Mr. Beck was formerly vice-president and general manager of the company.

Ellsworth M. Smith, formerly chief metallurgist of the Beryllium Corp., was recently named vice-president and chief metallurgist of Penn Precision Products, Inc., with headquarters in Reading, Pa.

Harry E. Miller has been appointed manager of the aluminum extrusion plant of Reynolds Metals Co. at Grand Rapids, Mich. Mr. Miller was transferred to Grand Rapids from the Reynolds extrusion plant at Phoenix, Ariz., where he was plant superintendent.

H. O. Proske, formerly service manager in the meter and valve division of Rockwell Mfg. Co., Pittsburgh, has been named national representative specializing in gas meter sales promotion. In his new position, Mr. Proske will supervise sales and production liaison between the firm's gas meter manufacturing plants and the sales force.

Alan Swabey, of Montreal, was recently elected vice-president of the Patent Institute of Canada. The Patent Institute is the governing body of the patent profession in Canada, and plays a leading role in patent and trademark legislation.

C. Ridgely Kemp, formerly vice-president in charge of production for Magnesium Co. of America, East Chicago, Ind., has been appointed to the newly created position of vice-president in charge of research and development. Prior to joining Magcoa in 1948, Mr. Kemp was with Dow Chemical Co., Midland, Mich.

Harris R. White is vice-president of the recently organized Tech Steel and Alloy Corp., Chicago.

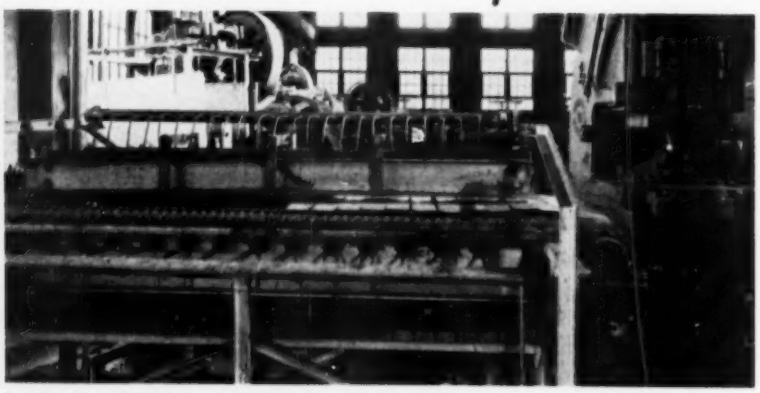
Walter E. Remmers is now chairman of two of Union Carbide and Carbon Corp.'s divisions, Electro Metallurgical Co. and the United States Vanadium Corp., as well as a member of the appropriations committee of Union Carbide. Mr. Remmers is also a vice-president of Union Carbide and Carbon Corp.

Wilson D. Trueblood, Jr., formerly in the Chicago office of Leeds & Northrup Co., has been promoted to district manager of the company's new office in Milwaukee.

M. L. Smith has rejoined Carboloy Department of General Electric Co., Detroit, as a marketing trainee in the permanent magnet field after two years in the Marine Corps. Mr. Smith holds a B. S. in metallurgy from the University of Notre Dame, and joined the General Electric Co.'s chemical and metallurgical engineering training program in 1949, transferring to Carboloy Department in 1950.

Raymond A. Talbot has been elected a vice-president of Industrial Steels, Inc., Cambridge, Mass., after 18 years as sales engineer for the firm.

Heats the Spot!



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. . . for standard tension, compression and transverse tests on metal (strip, spot weld, wire, etc.) plus plywood, bricks, cement, briquettes, textiles, rivets, insulating materials, plastics and many others.

DUAL CAPACITIES 10,000 and 1,000 lb. testing ranges.

ACCURACY to within ±1% of the indicated load or ±1 dial division, whichever is the greater.

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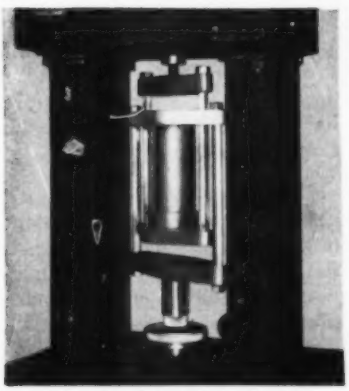
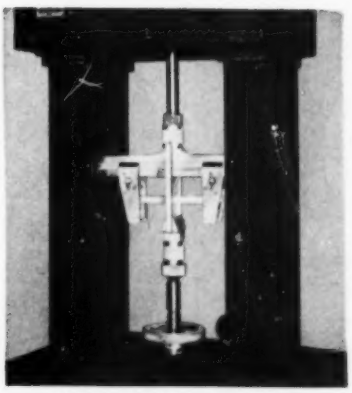
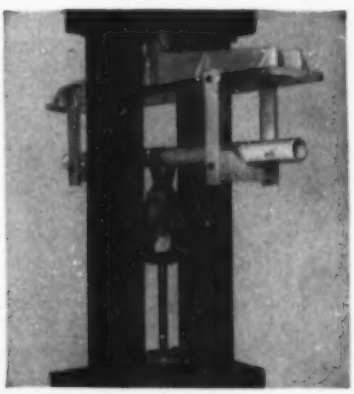
CONVENIENCE—Tools for all types of testing can be inserted quickly and easily, and all controls are readily accessible.



Compression Testing with an LC.



Flexure Testing with an LC.



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Testing & Balancing Machines

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Personals

Joseph Glyman has been added to the supervisory staff of the investment casting plant of Bone Engineering Corp., Glendale, Calif. Mr. Glyman holds a Master's degree in metallurgy from the University of Toronto, Canada, and at one time operated an investment casting plant.

Leon Siegel has resigned as chief chemist at the New Orleans tank engine plant of Chrysler Corp. to accept a position as manager of the El Paso, Tex., branch of Shilstone Testing Laboratories.

George L. Flint has been transferred from General Electric Co.'s nucleonics division at Hanford, Wash., to the company's switchgear and control division at Philadelphia. He is presently engaged in doing metallurgical engineering in the materials and processes laboratory.

James D. Duncan has accepted a position as research assistant with the University of California at Los Alamos, N. M., and is assigned to the chemistry and metallurgy division. Mr. Duncan was previously employed by Reynolds Metals Co. as tube mill metallurgist at their Phoenix, Ariz., works.

Neville S. Spence has a position with the Canadian Dept. of Mines and Technical Surveys, Mines Branch, Nuclear Metallurgy Section, attached to the Atomic Energy of Canada, Ltd., at Chalk River, Ont. For the past 7½ years Mr. Spence was with Dominion Magnesium, Ltd., Haley, Ont., during which time he held the positions of European technical representative, director of research and development, and more recently sales manager.

Oliver H. Cook is now employed as metallurgist for General Alloys Co., South Boston, Mass.

Wesley H. Train is now residing in California and is employed as a registered representative for Francis I. du Pont & Co., in Pasadena.

Gene P. Davis has been promoted to the position of assistant chief metallurgist for the Warner Gear Division of Borg-Warner Corp., in Muncie, Ind.

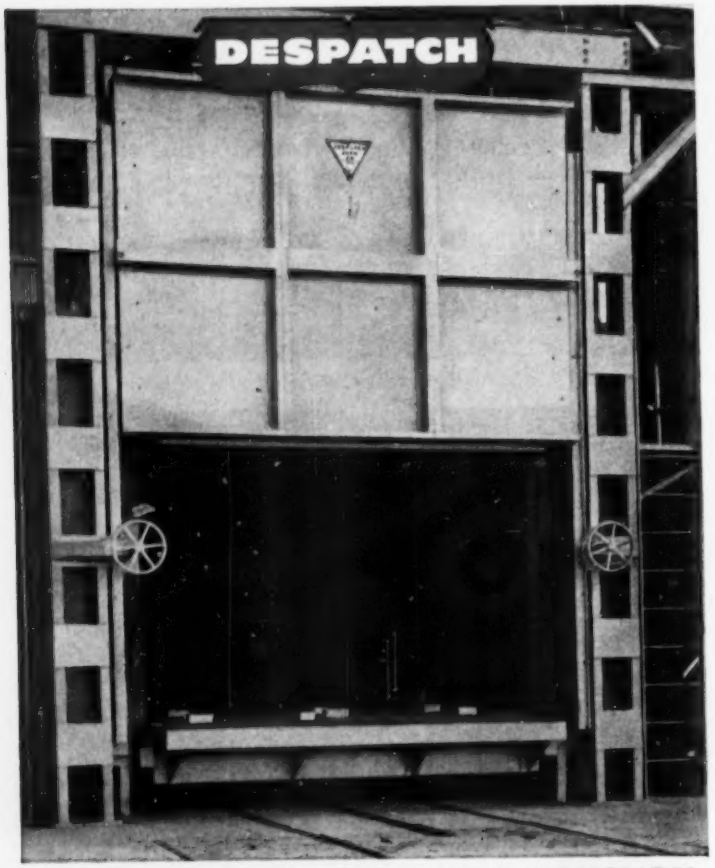
Guinn E. Metzger, after completing a year of postgraduate work and receiving the Diploma of the Imperial College at the Royal School of Mines in London, England, is now employed as metallurgist in the design and production department at the U. S. Naval Ordnance Test Station near Inyokern, Calif.

Lee S. Busch, formerly with P. R. Mallory & Co., Inc., Indianapolis, is now director of research for the Mallory-Sharon Titanium Corp., Niles, Ohio.

Earle S. Bidgood, formerly chief metallurgist in the laboratories of advanced research for Remington Rand, Inc., Bridgeport, Conn., is now chief chemist of the Stamford (Conn.) division of the Allen D. Cardwell Mfg. Corp.

William P. Koster has completed the work leading to a Ph.D. in metallurgical engineering at the University of Cincinnati, and is employed as assistant director of metallurgical research for Metcut Research Associates, Cincinnati.

Alan W. Postlethwaite has resigned from the Gillette Safety Razor Co., Boston, and is now employed by the Raytheon Mfg. Co.'s Receiving Tube Division in Newton, Mass., as a senior development engineer in germanium diode production.



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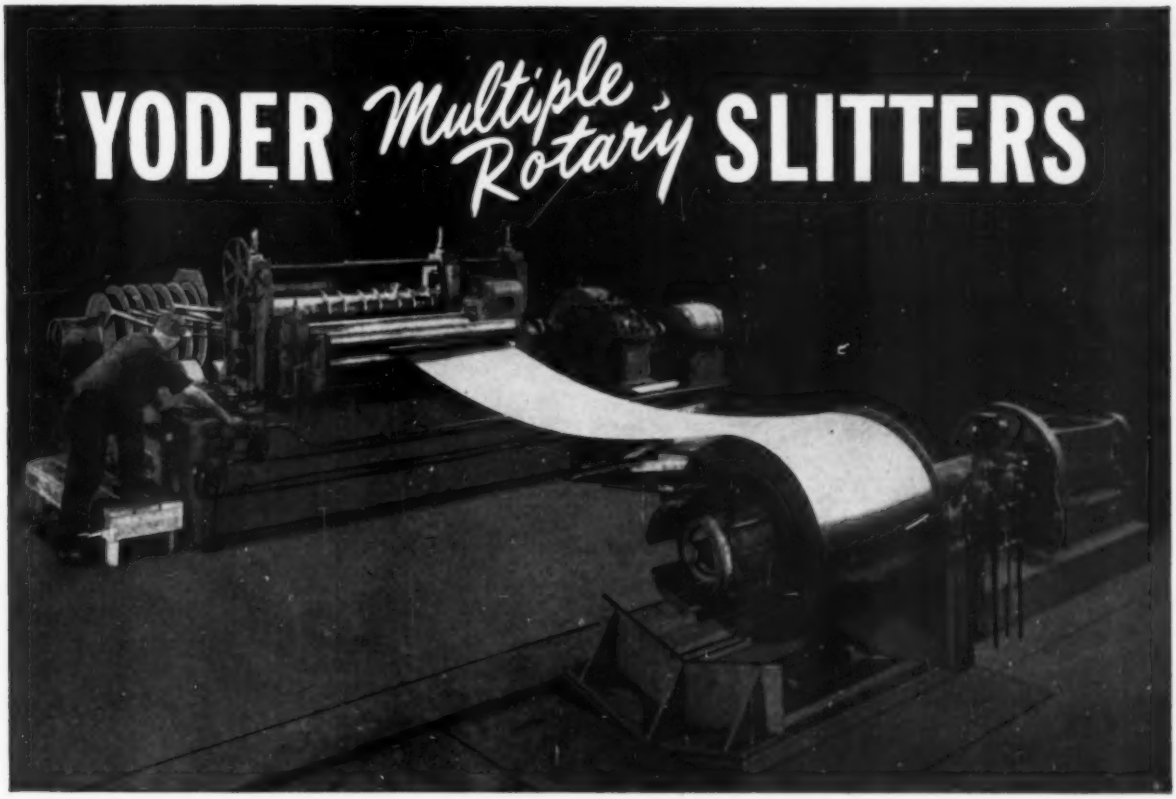
YODER *Multiple Rotary* SLITTERS



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1. Savings of $10 to $30 per ton by buying standard widths instead of slit strands. This saving alone often pays for the Slitter investment in a year or less.

2. You can buy standard widths competitively, wherever you can obtain the best quality, price and delivery.

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Yoder slitters, uncoilers, recoilers and other accessories are made in many sizes and capacities, from the smallest to the largest. The Yoder Slitter Book is a treatise on the economics as well as mechanics of slitter operation—send for it.

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- ★ **GANG SLITTING LINES for Coils and Sheets**
- ★ **PIPE and TUBE MILLS–cold forming and welding**

ENGINEERING YODER MANUFACTURING

Personals

Maurice J. Lynch, formerly in charge of the engineering department of the modern tool works division of the Consolidated Machine Tool Co. in Rochester, N. Y., is presently engaged as tool engineer for the Dorran Mfg. Co., Charlestown, Mass.

Bharat B. Bangrei, a 1953 graduate in metallurgical engineering from Colorado School of Mines, is now employed by Anaconda Copper Mining Co. at Anaconda Reduction Works in Butte, Mont.

William H. Tholke is now on the staff at the University of Cincinnati as an instructor in metallurgy.

Albert G. Haynes has relocated in Chicago as chief engineer for the Buell Mfg. Co., and is in charge of research, testing, development and design.

George F. Stradar has been promoted from metallurgist to chief metallurgist for Fairchild Camera & Instrument Corp., Long Island, N. Y.

Theodore J. Strater has been transferred from the South Chicago plant of Republic Steel Corp. to the Buffalo plant, with a promotion to mill metallurgist.

Michael J. Bolton has been appointed supervisor of materials in the engineering department of the Rome, Ga., plant of the General Electric Co.

Robert L. Fischer has resigned as staff metallurgist with Aluminum Co. of America to accept a position as metallurgical development engineer in the manufacturing research group at Plant No. 2 of the Boeing Airplane Co., Seattle, Wash.

J. N. Harris has retired after 28 years with Rockford Drop Forge Co., Rockford, Ill.

E. M. Doss has resigned his position with the Coast Mfg. & Supply Co., Livermore, Calif., to become project engineer with the National Glaco Chemical Co., a division of Ekco Products Co., and will be located in San Francisco.

William C. Neagley has been employed in the metallurgical department of the Chicago Pneumatic Tool Co. in Utica, N. Y., since being released from the Navy.

A. Donald Mead, a 1953 graduate of Case Institute of Technology with a B. S. in metallurgical engineering, has accepted a position with the Mesta Machine Co., Pittsburgh, as a supervisory trainee.

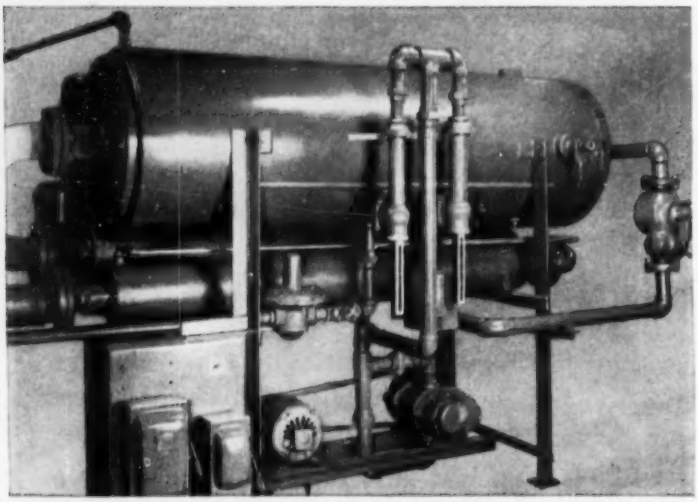
Robert L. Wayne has been appointed chief metallurgist of the New Bedford (Mass.) Defense Products, a division of the Firestone Tire & Rubber Co., Akron, Ohio, where he was formerly employed.

Eugene R. Andreotti, formerly employed as plant metallurgist at the Fansteel Metallurgical Corp., North Chicago, Ill., is now senior product engineer for Kwikset Powdered Metal Products, Anaheim, Calif.

William M. McCue, Jr., formerly a metallurgist for Wyman-Gordon Co., Worcester, Mass., is now a research associate in the research laboratory of the Heppenstall Co., Pittsburgh.

W. E. Bryden has been appointed sales manager of the Cooldige Corp., Middletown, Ohio. He was formerly associated with the Timken Roller Bearing Co., steel and tube division, for 16 years, and served in the steel division on the War Production Board, Washington, D. C., during World War II.

Both lean and rich gas ratios



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Answer *all* your standard requirements for bright or clean annealing and sintering. The Sargeant & Wilbur exothermic gas generator produces the controlled atmosphere you need — maintains constant gas mixture, lean or rich. Firing may be with manufactured, natural, propane or butane gas. Assured economy features are low maintenance cost, long satisfactory service life. S & W gas generators, both exothermic and endothermic types, are regularly supplied as standard units in capacities from 125 to 5000 C.F.H. Larger sizes will be made up readily to your order — and good service on all orders is our regular routine. To compare S & W performance, send your samples for processing — without obligation.

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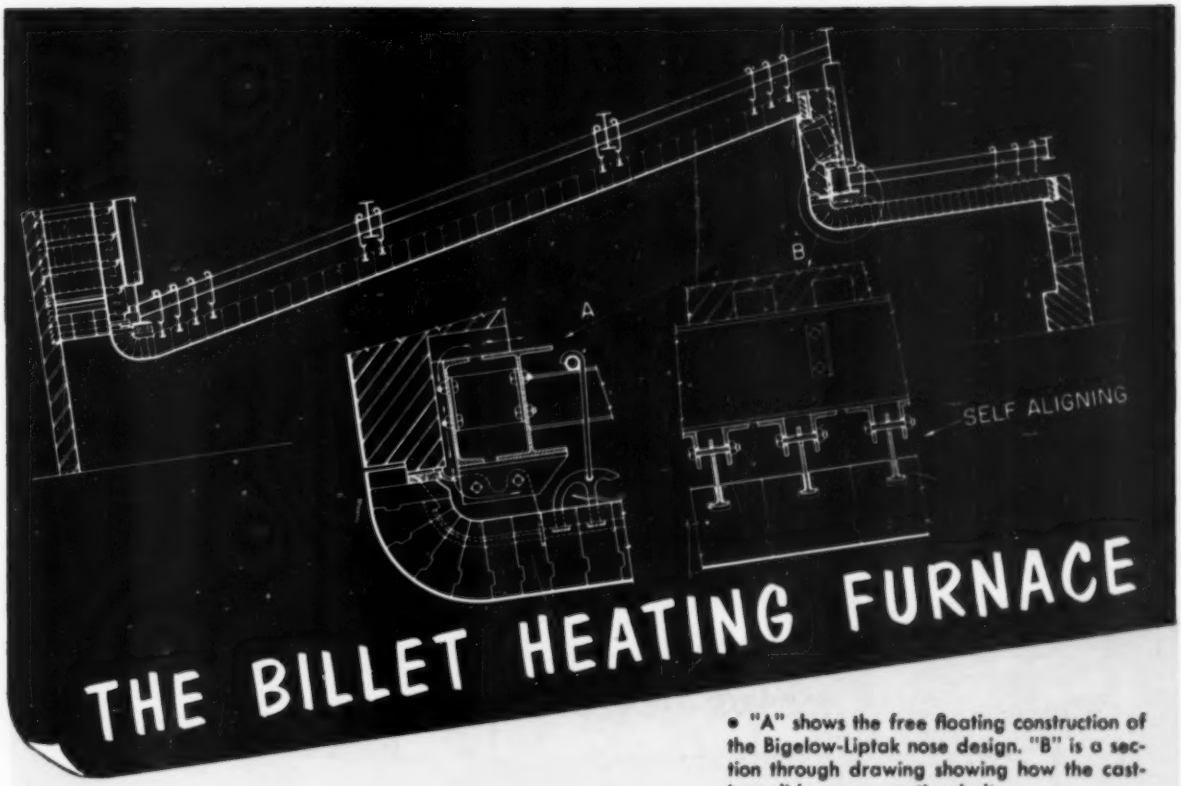
Atmosphere Generators • Ammonia Dissociators • Gas Conditioning Equipment



THE BILLET HEATING FURNACE

• "A" shows the free floating construction of the Bigelow-Liptak nose design. "B" is a section through drawing showing how the castings slide on supporting bolts.

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A new radial nose tile for billet heating furnaces. Previously, cumulative expansions of rigidly hung nose tile in wide metallurgical furnaces had caused mechanical failures of tile and castings . . . plus "shut down" losses of production time.

THE ANSWER . . .

A *free floating* nose designed by Bigelow-Liptak engineers to control expansion movements at this highly vulnerable point. The free floating feature is only possible with unit-suspension construction . . . another Bigelow-Liptak development.

THE RESULT . . .

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Personals

A. A. Conrad, Jr., formerly chief metallurgist for Precision Metalsmiths, Inc., Cleveland, is now metallurgist in the technical section, International Nickel Co., Detroit.

M. G. Manker, formerly Philadelphia district sales manager for Copperweld Steel Co., Warren, Ohio, is now district sales manager in the Syracuse, N. Y., area.

John C. Traux, who is employed by the Cold Metal Products Co., Youngstown, Ohio, has been transferred to the Chicago district sales office as a steel salesman.

Douglas M. Brown, Jr. is now process engineer in the Schenectady steel foundries of General Electric.

W. D. Labrum has transferred from duty as assistant shop superintendent at the Puget Sound Naval Shipyard to repair officer aboard the USS Kermit Roosevelt.

William C. Shirley, who was formerly chief metallurgist and laboratories director for the U. S. Reduction Co., East Chicago, Ind., is now vice-president and works manager of Wabash Smelting Co., Wabash, Ind.

William E. R. Watt, a June 1953 graduate from Lafayette College, is now production metallurgist with Aluminum Co. of America, New Kensington, Pa.

George E. Dalbey has retired from the Mare Island Naval Shipyard where he has been supervising metallurgist in the foundry. Mr. Dalbey is now residing in Lake Wales, Fla., and will do consultant work in general metallurgy, sand, molding and foundry metallurgical problems.

Arthur G. Metcalfe, formerly research metallurgist at Deloro (Ont.) Smelting and Refining Co., is now a research metallurgist at the Armour Research Foundation of the Illinois Institute of Technology.

Frank Dreher, formerly metallurgical engineer in the Philadelphia plant of the Budd Co., has been transferred to the company's new Gary, Ind., plant as metallurgist in charge of the laboratory.

A. M. Talbot, who for the past 18 years has been with the International Nickel Co., Inc., in the research laboratory at Bayonne, N. J., as head of the iron alloys research section, has joined the Microcast Division of Austenal Laboratories, Inc., as technical director.

R. J. Johnson is now associated with the International Nickel Co., Inc., in the development and research division of the Pittsburgh technical section.

Harold T. Harrison has accepted a position as metallurgist with the Presmet Corp., Worcester, Mass., after having been research metallurgist for the National Cash Register Co. in Dayton, Ohio.

Maurice J. Condon is now senior structures materials engineer in the engineering department of Chance Vought Aircraft Division of United Aircraft Corp., Dallas, Tex. He was formerly metallographer at the Peoria, Ill., plant of the Caterpillar Tractor Co.

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Show the exact hardness of your metals before and after heat-treating, to reduce tool wear and breakage and to speed up production.

Ames Portable Hardness Testers are light in weight and are carried to the work. Tests are easy to make and accurate, requiring no skill.

Ames Portable Testers are used to test flats, rounds, strip, tubing, wire, etc., without cutting off specimens. Saws, gears, knives and large irregular shapes are tested while assembled. Readings are direct in the Rockwell Scales.

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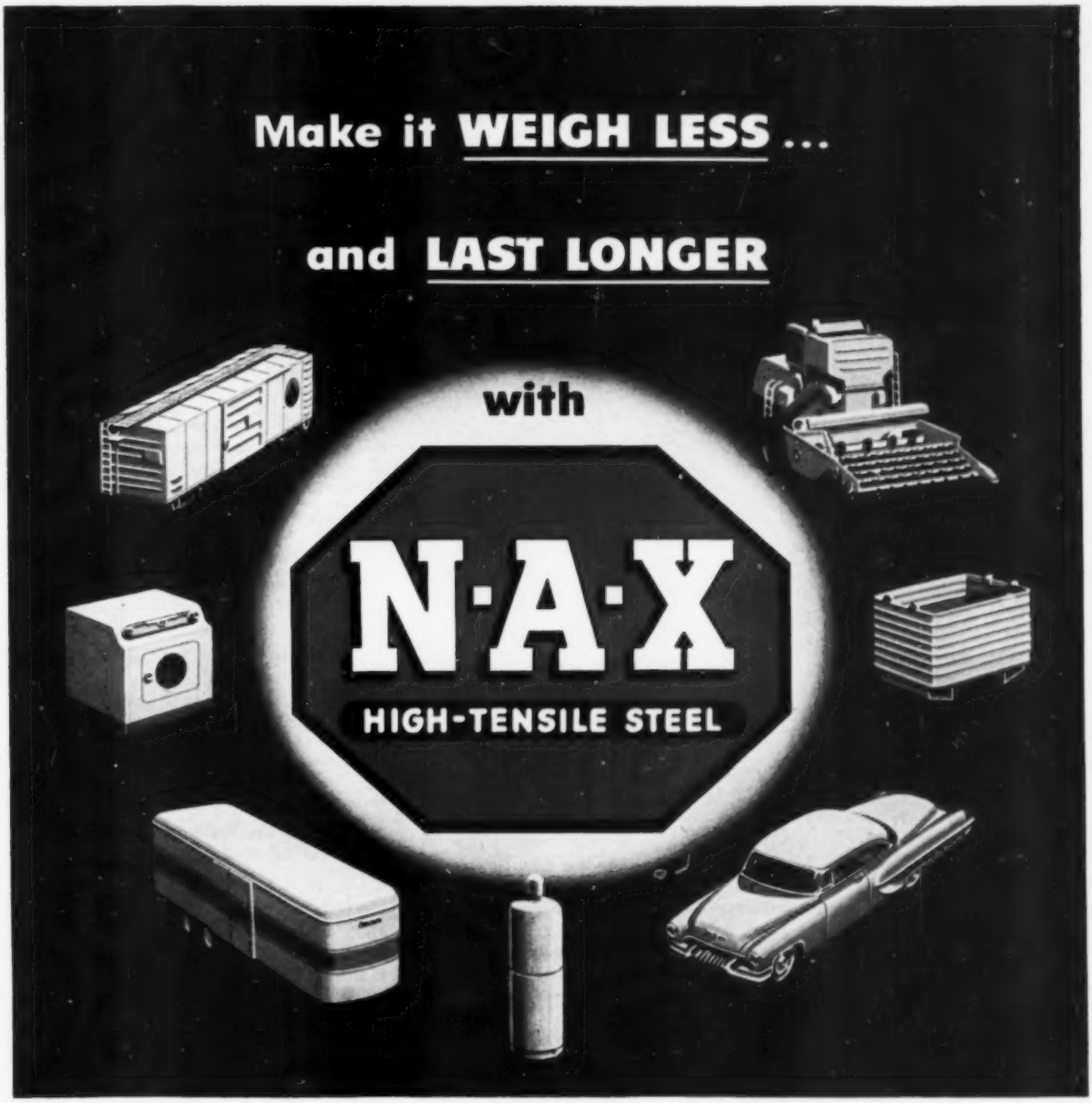
Make it WEIGH LESS ...

and LAST LONGER



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It has greater resistance to abrasion or wear.
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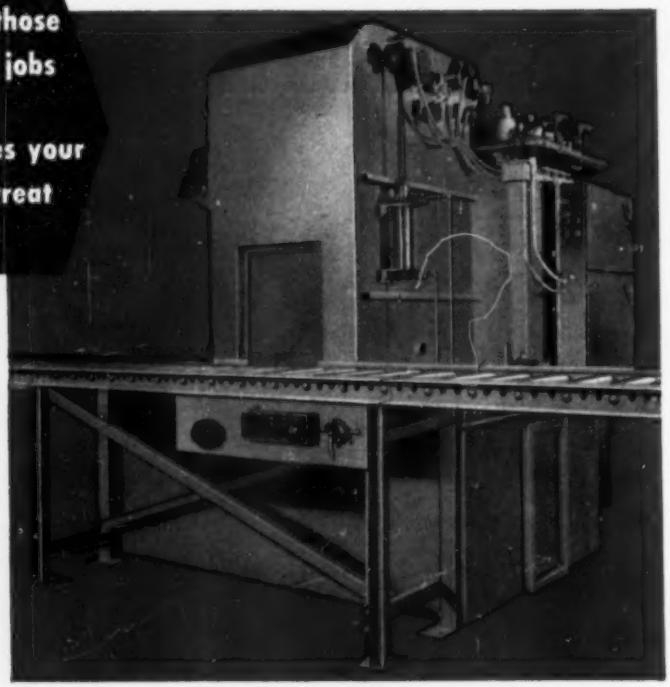
Licks those tough jobs

Slashes your heat treat costs!



"NO-GAP" OPERATION—A batch type furnace with less than 30 seconds between loads. Work chamber is never exposed to air. Loading is accomplished while slow cooling or quenching a previous load.

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Personals

Laurence W. Gauthier, formerly supervisor of the chemical and metallurgical engineering department in the Automatic Transmission Div. of the Ford Motor Co. at the Cincinnati plant, is now manager of the chemical and metallurgical engineering department at the Livonia, Mich., plant.

E. J. Ramaley, formerly engaged in industrial research at Battelle Memorial Institute and more recently in manufacturing research at Lockheed Aircraft Corp., Burbank, Calif., has opened an office in Columbus, Ohio, to operate a consulting service in the solution of manufacturing problems in metals fabrication.

Edmund C. Franz has been transferred from the Cleveland research division of the Aluminum Co. of America to the aluminum research laboratories of the company at New Kensington, Pa.

Louis Mager is now a sales metallurgist for the New York district of the A. F. Holden Co.

Stephen Foldes has resigned from the Institute for the Study of Metals, University of Chicago, where he was on the staff as a metallurgist, to join the Beryllium Corp., Reading, Pa., in a similar capacity.

R. M. Garrison is now manager of manufacturing for Hanson-Van Winkel-Munning Co., Matawan, N.J.

J. V. Marsilio has resigned as alloy conservation engineer with the Bethlehem Steel Co. to accept the position of metallurgical engineer in charge of the materials testing laboratory and materials specification department of the Alco Products Div. of the American Locomotive Co. in Dunkirk, N. Y.

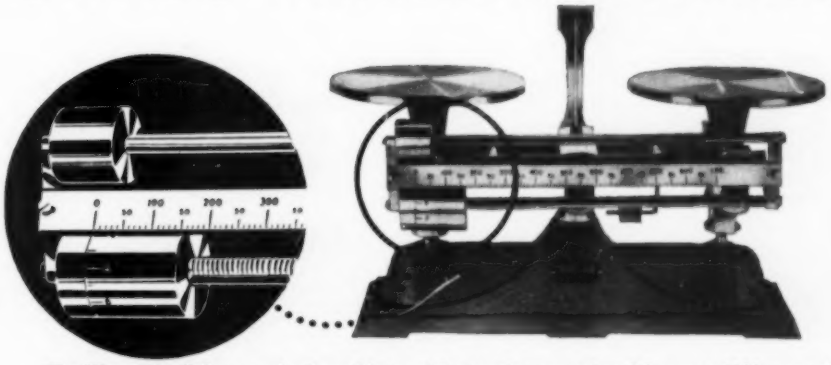
L. McD. Schetky, formerly research associate at Rensselaer Polytechnic Institute working in welding research in the department of metallurgy, has joined the staff of the Massachusetts Institute of Technology as research associate in the metals processing group in the department of metallurgy. His position involves investigations in powder metallurgy, joining and forming.

FOR LABORATORIES AND PLANTS

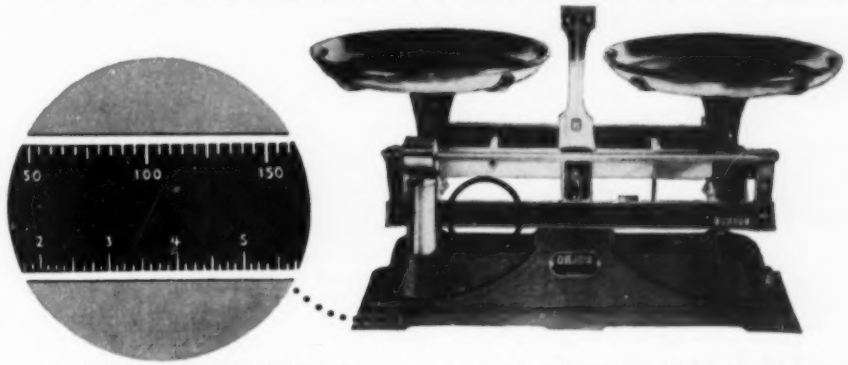
The New OHAUS Industrial Balances

Features

- **Light weight — high strength Duralumin beam**
- **Capacity to 5 kg... sensitivity 0.5 gm**
- **Patented self-aligning agate bearings**
- **Precision hollow ground tool steel knife edges**
- **Dust proof bearing covers**
- **Clear reading etched graduated beams**



The Micrometer Poise . . . makes it possible to weigh a complete range from 0.5 gram to 1000 grams without the use of loose weights. Poise is moved along the beam for rapid traverse, rotated for final positioning.



Single Beam with Dual Calibrations . . . both metric and avoirdupois standards make the balances extremely versatile. All models have a capacity of 5 kilograms and a sensitivity of 0.5 gram.

H-2845 Balance with Micrometer Poise. Capacity 5 kg, sensitivity 0.5 gram; beam calibrated 1000 x 0.5 gram. Furnished with 7" diameter satin finish stainless steel plates. Equipped with tare beam and poise of 1 pound capacity **$90.00**

H-2845-10 Balance with Micrometer Poise. Capacity 5 kg, sensitivity 0.5 gram; beam calibrated 1000 x 0.5 gram. Furnished with 9" diameter nickel plated brass pans. The removable pans are of equal weight and can be used interchangeably on either side of the balance. With tare beam and poise of 1 pound capacity. **$95.00**

H-2846A Balance — Single beam with dual calibrations. Furnished with 7" diameter stainless steel plates; beam calibrated 500 x 5 grams and 16 x ⅛ ounce. Complete with tare beam of 1 pound capacity. **$80.00**

H-2846B Balance — Single beam with dual calibrations. Furnished with 7" diameter stainless steel plates; beam calibrated 100 x 1 gram and 4 x ½₂ ounce. Complete with tare beam of 1 pound capacity . **$77.50**

H-2847A Balance — Single beam with dual calibrations. Furnished with 9" diameter nickel plated brass pans; beam calibrated 500 x 5 gram and 16 x ⅛ ounce. Complete with tare beam of 1 pound capacity . **$85.00**

H-2847B Balance — Single beam with dual calibrations. Furnished with 9" diameter nickel plated brass pans; beam calibrated 100 x 1 gram and 4 x ½₂ ounce. Complete with tare beam of 1 pound capacity . . **$82.50**

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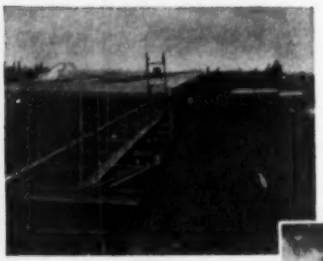

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Here's a Finished Baking Oven Installation. It actually enhances the plant picture—A WORTHY CAPITAL ASSET.

Paint Finishing Systems are not "shelf" packages. In all cases, they must be designed to meet the needs and fit within the facilities where they are to be installed. The illustrations show how P-D engineers overcame problems of locating Baking Oven installations. They "took to the air"— installed them on plant roofs with conveyor feeds from other floor levels — eliminating plant expansion while increasing its capital worth.

For gaining the utmost in efficiency, economy, and surety of operation to meet your Finishing System requirements, it is most important to check your NEEDS with a firm that has the "know-how." Regardless of the size installation, it does not pay to "pick" and "choose" components separately. Peters-Dalton, with 25 years of Finishing System leadership and experience, offers expert engineering and design. P-D engineers lay out the complete Finishing System to meet whatever requirements and space limitations necessary for a satisfactory installation in your plant.

A Finishing System installed by P-D is tops in efficiency and economy because it is plant engineered and produced step by step for you and you only.

A P-D installation means one responsibility for final satisfactory results—means the performance of a Finishing System that you can rely upon for smooth, efficient, integrated operation and high quality work at lowest possible costs.

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Recrystallization Behavior of Aluminum*

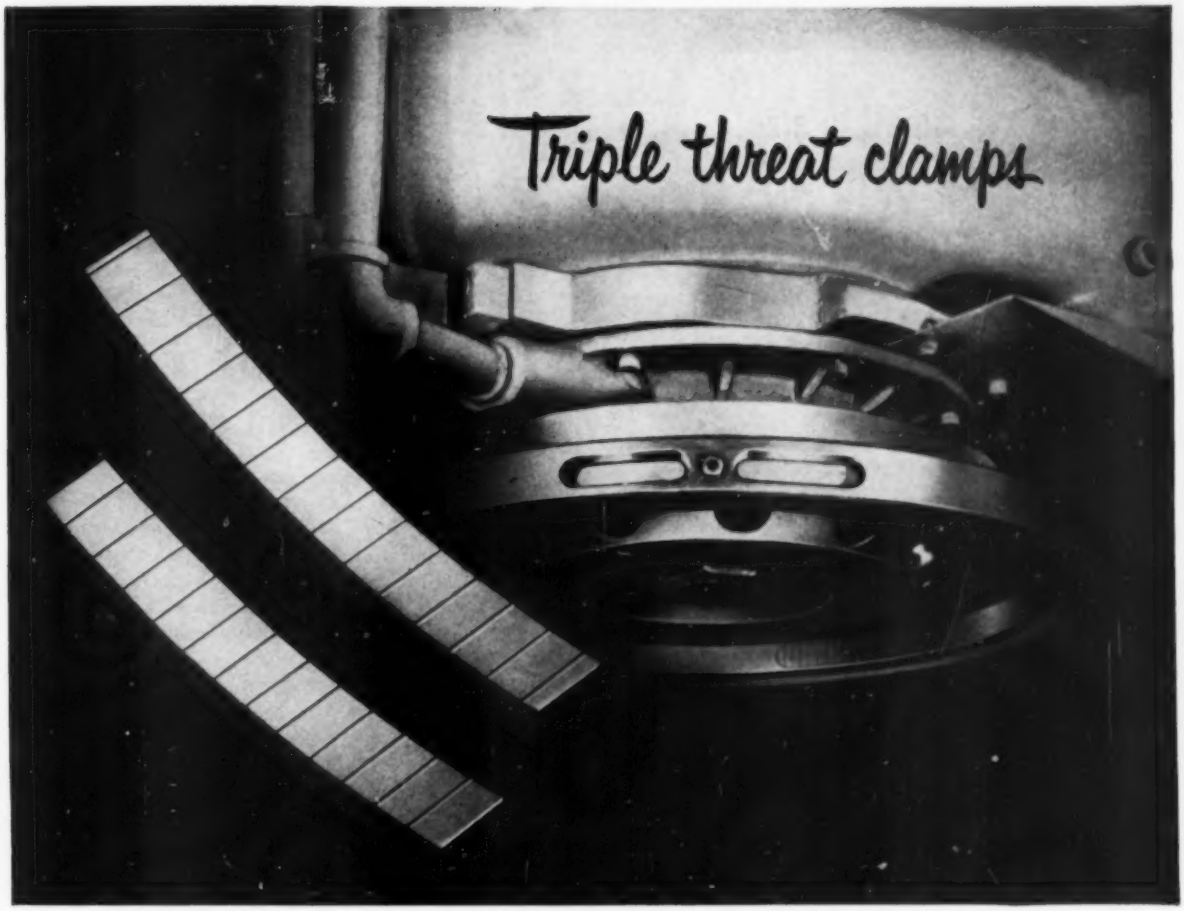
IN THIS STUDY of the recrystallization behavior of aluminum and some of its commercial alloys, particular attention was given to critical strains and associated coarse grain sizes, and effect of original grain size.

The materials studied were superpurity aluminum, commercial-purity aluminum, and four aluminum alloys containing, respectively, 2% magnesium, 1% magnesium, 1% silicon, 1¼% manganese, and 4.75% copper (duralumin-type). These materials were received as cold rolled sheet of various tempers. Except for superpurity aluminum, a batch containing the various tempers was annealed at an appropriate temperature for each material to obtain a range of initial grain sizes. If the as-received material did not yield a sufficient range of grain sizes upon annealing, it was reworked suitably, and was then reannealed so as to obtain grains of the desired sizes. In order to produce various degrees of coalescence, as-received samples of super-purity aluminum were annealed at various temperatures from 530 to 970° F.

Two approaches were used to obtain a range of strains in a given specimen. One was the use of tapered tensile specimens cut from worked sheets and given the predetermined annealing treatment to establish a range of grain sizes. A range in strains is produced by stretching such a specimen. This tapered specimen was used for the two grades of aluminum, and the alloys containing magnesium, or magnesium and silicon. However, critical strains for the alloy with 1¼% manganese, and the duralumin-type alloy were greater than could be obtained with the tapered specimen, so the second approach was to "wedge-roll" the annealed sheet. This was done by bringing a pair of rolls closer together at one end than the other and passing the strips through with the length parallel to the roll axes. Such a wedge-rolled specimen yielded strains from about

(Continued on p. 132)

*Digest of "Critical-Strain Effects in Cold Worked Wrought Aluminum and Its Alloys", by W. M. Williams and R. Eborall, *Journal* of the Institute of Metals, Vol. 81, July 1953, p. 501-512.



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The Blanchard Machine Co. solved three problems at once by using beryllium copper in the wheel holder of its surface grinder.

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This application shows why more and more designers consider Berylco an ideal engineering material. No other alloy combines such desirable properties as corrosion resistance, strength, conductivity, fatigue resistance, and ease of forming. To find out what Berylco can do for you, for engineering help or for sample material, write any of the sales offices listed below.

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Recrystallization Behavior of Aluminum

(Continued from p. 130)

10 to 75% with negligible lateral spread.

The strained specimens were recrystallized at various temperatures with annealing time being held constant at 30 min. The recrystallized specimens were polished, etched and examined for grain size. Grain sizes were related to strain values before recrystallization. Critical strain was taken as the strain at the junction between the recrystallized and unrecrystallized portions, the exact strain being that beyond which none of the original structure was retained.

The results of the investigation were compared to a set of empirical rules describing the effects of strain, annealing temperature, and initial grain size on critical strains and final grain sizes.

The first rule is that when a metal is cold worked and then annealed, as-recrystallized grain size decreases as the amount of deformation before annealing is increased, and is substantially independent of annealing temperature. It was found in this investigation that recrystallizaion temperature did have a slight effect on the final grain size; for a given strain the final grain size was, in general, finer for the higher annealing temperature. Super-purity aluminum showed the effect most strongly, and in all tests the largest effect is at low strains.

The second rule is that with a given annealing treatment, there is a critical strain below which complete recrystallization does not occur. This critical strain produces the largest grains after annealing. The third rule states that the critical strain is higher with lower annealing temperatures. The investigators found no departure from these two rules.

The fourth rule is as follows: For a given annealing temperature, the critical strain is higher with the larger initial grain size; and, because the recrystallized grain size is mainly dependent upon strain, the maximum size to which it can be produced by the given annealing treatment is smaller for initially coarse material than for fine-grained material.

This investigation leads to some qualification of the fourth rule, since

(Continued on p. 134)

Here's one you'll want to bite on! It's Formbrite

FISH find this particular line of brass spinners so attractive that fishermen's demands have built annual sales of the Aeroplane Tackle Manufacturing Company of Denver to more than two million lures of all types.

The high finish on the spinner is part of the secret. While the cost of producing this is of no interest to the fish, it is to the manufacturer. Recently all brass orders were changed to Formbrite*, the superior ANACONDA Drawing Brass that has enabled this firm to cut polishing costs over 25%, and on several stamped products to produce the required finish by tumbling only prior to lacquering or plating.

Formbrite, with its superfine grain, provides a surface far superior to ordinary drawing brass. It is stronger, harder, more scratch-resistant than ordinary brass, yet retains remarkable ductility for forming and drawing. It's a premium product at a non-premium price. If these features lure you, we should like to show you how this better brass can cut your product's finishing costs. Or write for Publication B-39 to *The American Brass Company, General Offices, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Limited, New Toronto, Ontario.*

Upper lure is Formbrite. Lower one is made of ANACONDA Fancy Pattern Embossed Brass.

Thirty-five years ago a fisherman, disgusted with his luck, cut up an old brass bait box to make himself a spinner resembling an old-time airplane propeller. Both fish and fisherman liked it so much, he started what is now a big and thriving business.

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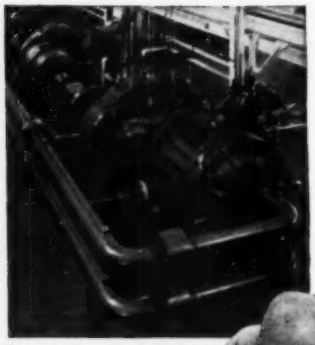

Upper: Waterbury Size 300 pump under test. Lower: Lebanon casting, machined ready for fabrication.

CIRCLE L

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IN WATERBURY TOOL'S SIZE 300 PUMPS—largest oil hydraulic high-pressure pumps ever built—dependable Lebanon CIRCLE (L) castings help confine the tremendous forces developed. These pumps are the working heart of the world's largest tube reducing machine being built by E. W. Bliss Company for Tube Reducing Corporation. On the tube reducer these pumps will move the equivalent of three fully loaded freight cars three feet forward and three feet backward—every two seconds! Each pump weighs 21½ tons, is capable of delivering 2300 gallons per minute at pressures up to 3000 p.s.i. and can transmit up to 4000 H.P.

Lebanon steel castings in the pumps for this extraordinary machine that cold rolls tubing up to 18" O.D., were engineered and built for enduring service.

●See—STEEL WITH A THOUSAND QUALITIES—37-min., 16 mm, semi-technical, full-color, sound film on the making of steel castings. For information write: Dept. H, Lebanon Steel Foundry.

LEBANON Castings

CARBON, SPECIAL ALLOY AND STAINLESS STEEL

CIRCLE L

LEBANON STEEL FOUNDRY LEBANON, PA.

Recrystallization Behavior of Aluminum

(Continued from p. 132)

it was found that recrystallized grain size may, for given deformation and annealing temperature, depend on its initial size. The effect is especially noticeable in super-purity aluminum and for small deformation, with the result that for this material at high temperatures, the maximum size obtainable by critical strain increases with initial grain size instead of decreasing as predicted. The first part of the rule, however, that critical strain increases with initial grain size, remains true in practically all cases.

There is little in the literature on the effect of alloying on recrystallization. In this investigation it has not been found possible to generalize in any useful way on the effects of alloying on the grain size produced on recrystallization. The most striking effect of composition observed is that on critical strain, and alloying elements and impurities in general raise the critical strain. Manganese appears to be most effective in this way, and magnesium least effective. For the duralumin-type alloy, critical strain values were much larger for material quenched from 930° F. than from 795° F., presumably because of the greater amount of alloying elements in solution.

R. W. LINDSAY

Test Instruments Using Eddy-Current Principle*

NONDESTRUCTIVE testing has become most important now that each part placed into use must give long service; such service can be obtained only if the part is tested for fitness. As new problems in testing arise, new means and methods must be developed to cope with them and aid industry in not only maintaining but creating new standards of quality. A considerable amount of basic theoretical, experimental and developmental work has been carried on since 1935 by Friedrich Forster, formerly with the Kaiser Wilhelm

(Continued on p. 136)

*Digest of "Industrial Application of Eddy-Current Testing", by William A. Cannon, Jr., *Nondestructive Testing*, Vol. 11, May 1953, p. 30-33.

These features are standard in a *CVC* vacuum furnace

1. Sight window
2. Properly located mold port
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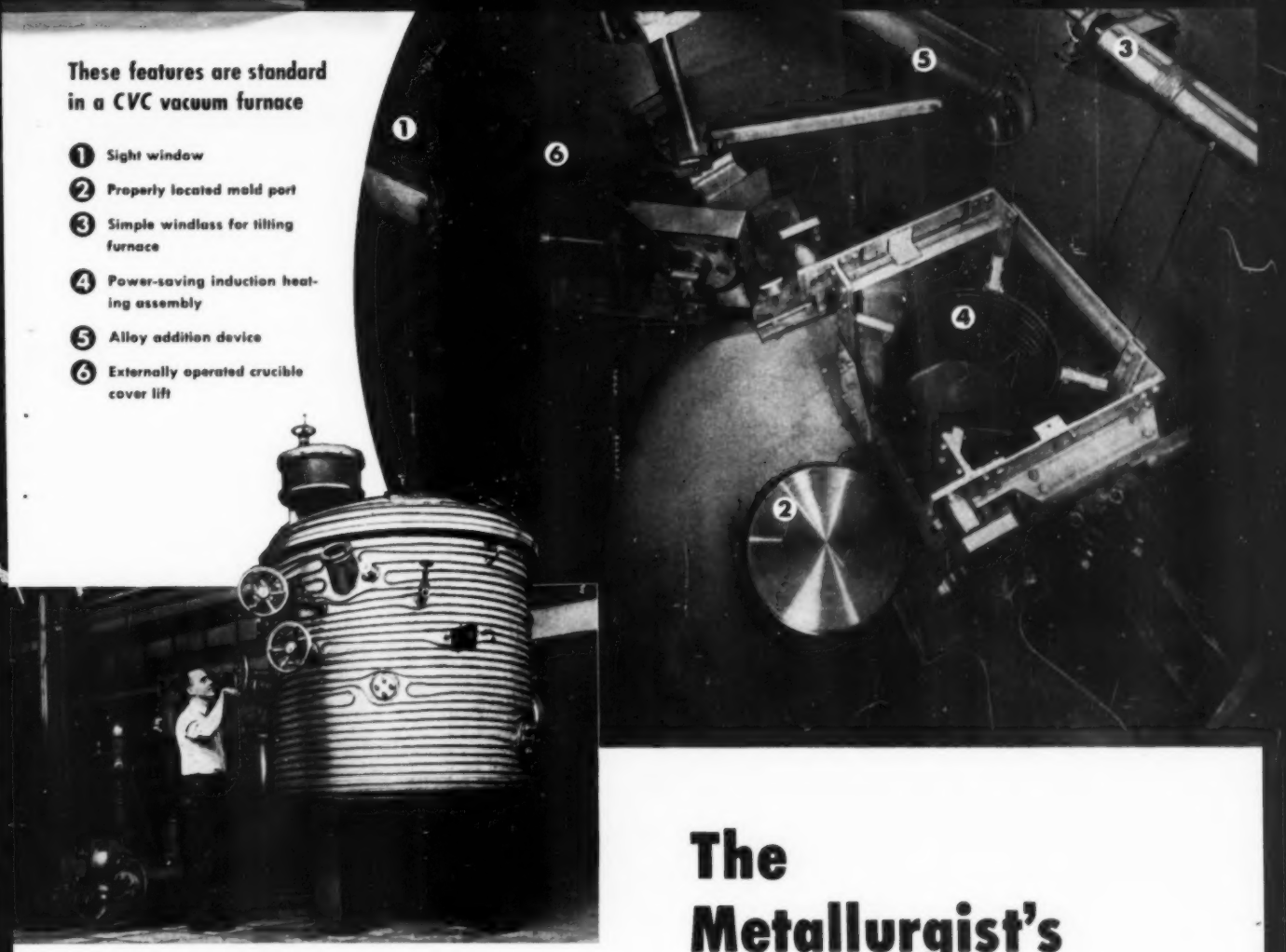

CVC's sixty-six inch high vacuum melting and casting furnace

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a CVC *high vacuum* furnace

When you invest in a *high vacuum* furnace, you want to buy—versatility—good mechanical and electrical design—and a *vacuum system* that will *pump to* and *hold at* the desired pressure, no matter what the gas load.

This is exactly what you receive in a *CVC high vacuum* furnace. *CVC*, with years of engineering experience in the high vacuum field, has solved such problems as producing vacuum tight seals, providing insulation under vacuum, handling the volatile components of the melt, and adding to the melt.

Whether you need a *high vacuum* furnace for laboratory or production use, *CVC* can meet your requirements. Feel free to consult with our metallurgical experts. ***Consolidated Vacuum Corporation; Rochester 3, New York.*** (A subsidiary of Consolidated Engineering Corporation, Pasadena, California.)

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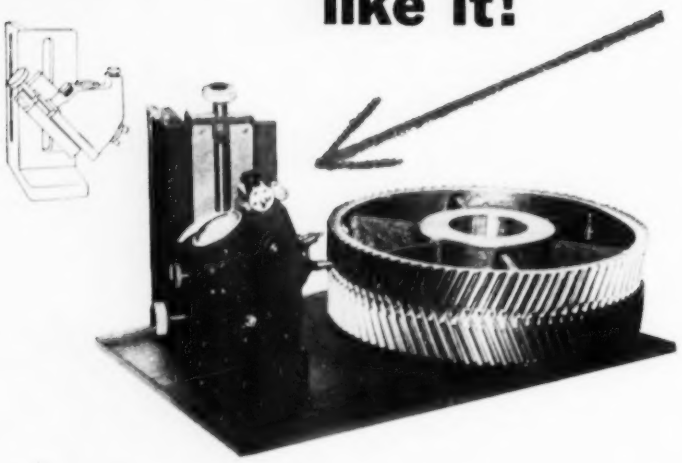

penetrascope
metal hardness tester

No clamps needed with this new, semi-portable Multiple-Angle Metal Hardness Tester. For a combination of accuracy and versatility, there is nothing like it in American industry today.

The Multiple-Angle Penetrascope illustrated above was developed for testing the many parts and places inaccessible when clamps are used — gear teeth roots and large bearing races, for example. The Penetrascope is movably mounted on a magnetic stand holding the unit firmly to a ferrous surface on which the object to be tested is also set securely. Adaptability is obtained by angling the stand on the ferrous surface, by angling the Penetrascope on its stand, and by adjusting the height of the Penetrascope on the stand.

For more accessible work, the basic Penetrascope is available with a variety of C-Clamps and Magnetic Clamps. The Penetrascope employs a 136° pyramidal diamond indenter and loads from 1 kg. to 30 kg. Extremely accurate results are obtained in the range 16 to 800/1000 D.P.H., with excellent comparative results up to 1500 D.P.H.

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1. **Accurate** — Extremely accurate from 16 to 800/1000 D.P.H.
2. **Versatile** — Capable of conventional and multiple-angle testing of large or small pieces; pieces can be tested at site.
3. **Portable** — Basic unit weighs about 18 pounds net; extra weight of semi-portable multiple-angle unit is more than offset by its versatility.
4. **Minimum marring** — light loads permit minute impressions, considered by many to be non-destructive.

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Test Instruments Using Eddy-Current Principle

(Continued from p. 134)

Institut, and now director of Dr. Forster Institut, Reutlingen, Germany. An integrated group of electronic nondestructive test instruments has been introduced by the Magnaflux Corp.; the majority of these utilize eddy-current principles, others use differential reluctance, and still others differential magnetic fields. The units have special coils or hand-held pick-ups. Results are presented and interpreted on either cathode-ray tubes, calibrated meters, or both. For applications in the production line, some instruments are used for automatic sorting, others to identify parts which are outside specified tolerance or to adjust manufacturing machinery.

The electrical conductivity of nonferrous metal products such as ingots, forgings, castings and stampings of various sizes and shapes can be read directly with the "Magnatest FM-100" conductivity meter without passing currents through the part. The conductivity is read directly on the main dial of a bridge circuit. An eddy current is induced in the test part by a detector which forms one arm of the bridge circuit. The impedance of the detector will vary, depending upon the conductivity of the material on which it is placed, and will unbalance the bridge. Balance is restored by adjusting the main dial. A 60-kc. oscillator is the source of the signal which is amplified and fed to the bridge circuit. The accuracy is within 1% of a full scale, which is from 8 to 103% International Annealed Copper Standard.

The detector should be placed on a plane surface with a minimum diameter of 0.400 in. Correction factors can be applied if surfaces of pronounced curvature are tested. The measurements are independent of the thickness of the material, provided the material is thicker than the depth of penetration of the eddy currents, the penetration being 0.030 in. for materials with a conductivity of approximately 98%, and 0.080 in. for conductivities of 12%. Thin nonconducting surface layers such as scale and oxides do not materially affect the accuracy.

The instrument can be used for

(Continued on p. 138)

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ACP metal protective chemicals include: protective coating chemicals for steel, zinc and aluminum; metal cleaners and rust removers; final rinse controls; pickling acid inhibitors; copper coating chemicals; soldering fluxes; alkali cleaners and addition agents; copper stripping and brightening solutions.

PAINT BONDING

"GRANODINE"® zinc phosphate coatings improve paint adhesion on automobiles, refrigerators, projectiles, rockets, and many other steel and iron fabricated units or components.

"LITHOFORM"® zinc phosphate coatings, make paint stick to galvanized iron and other zinc and cadmium surfaces.

"ALODINE"® protective coatings provide improved paint adhesion and high corrosion-resistance for aircraft and aircraft parts, awnings, wall tile, signs, bazookas, and many other products made of aluminum.

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"PERMADINE"® zinc phosphate coatings provide rust and corrosion proofing for nuts, bolts, screws, hardware, tools, guns, cartridge clips, and many other industrial and ordnance items.

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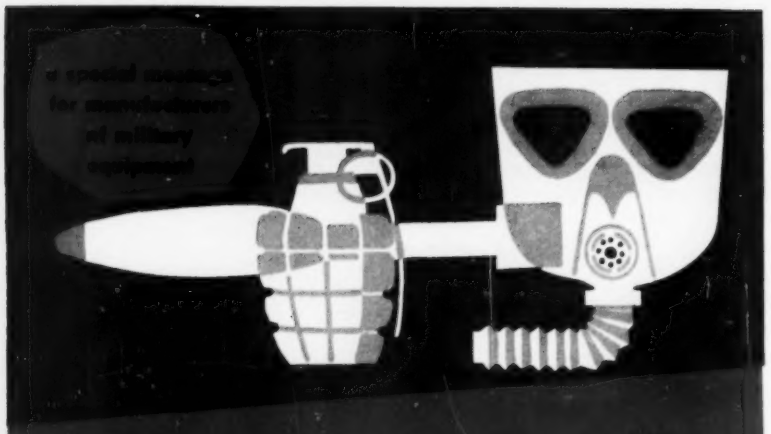

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A-XS-1607 QQ-P-416 QQ-Z-325 MIL-3151—
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ON ALUMINUM Iridite gives you a choice of natural aluminum, a golden yellow or dye colored finishes. No special racks. No high temperatures. No long immersion. Process in bulk.

ON MAGNESIUM Iridite provides a highly protective film in deepening shades of brown. No boiling, elaborate cleaning or long immersions.

AND IRIDITE IS EASY TO APPLY. Goes on at room temperature by dip, brush or spray. No electrolysis. No special equipment. No exhausts. No specially trained operators. Single dip for basic coatings. Double dip for dye colors. The protective Iridite coating is not a superimposed film, cannot flake, chip or peel.

WANT TO KNOW MORE? We'll gladly treat samples or send you complete data. Write direct or call in your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified telephone book.

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Test Instruments Using Eddy-Current Principle

(Continued from p. 136)

tests other than direct conductivity measurements – namely, measuring the Brinell hardness of light metals, such as aluminum and magnesium if alloy content and heat treatment are known; sorting and identifying mixed parts, provided the average conductivity values for the groups are sufficiently different; and distinguishing different alloys of the same base metal where the heat treatment can be controlled.

Longitudinal cracks, seams, inclusions, and diameter changes in nonferrous wire can be located and visually indicated with the "Magnatest FW-200." This instrument passes the wire to be inspected through a test coil and by means of a memory circuit the signal is compared with that obtained from the standard sample. The controls are set so that a horizontal straight line appears on the cathode-ray screen when a wire sample known to be free from cracks and of the proper diameter is placed in the test coil. The impedance of the test coil is changed if the wire has a crack or diameter variation. Diameter changes appear as angular displacements of the horizontal line. Cracks are shown when the straight line opens into an elliptical figure. A calibrated graph may be placed over the tube quantitative measurement.

Direct readings of the thickness of nonconductive coating on a nonmagnetic base metal are given by "Magnatest FT-400." The readings are independent of the base metal and are accurate to approximately 2% of the coating thickness. A typical unit could have three ranges, from 0 to 0.002, 0 to 0.004, and 0 to 0.020 in. full scale. The signal from the oscillator is amplified and fed to the detector which induces eddy-current into the base metal. The separation of the detector from the base metal (that is, the coating thickness) is an inverse function of the strength of the voltage generated by the eddy currents. The change in reflected impedance of the detector is observed as a voltage difference, and measured with a vacuum-tube voltmeter directly in thousandths of an inch.

The thickness of nonmagnetic, conductive or nonconductive coatings on

(Continued on p. 140)

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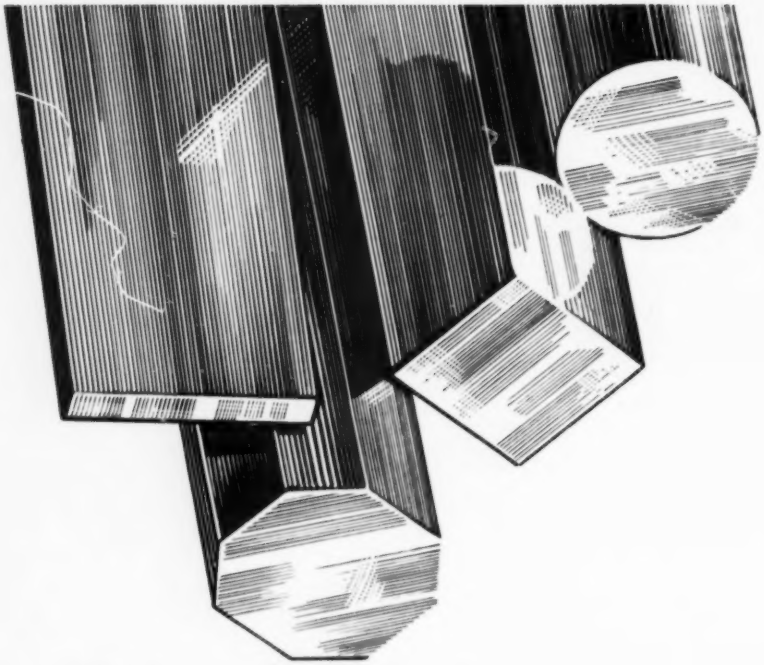

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Test Instruments Using Eddy-Current Principle

(Continued from p. 138)

any magnetic base can be measured by "Magnatest FT-300." The instrument is calibrated directly in thickness units and is available with dual ranges, from 0.0 to 0.004 and 0.0 to 0.020 in. full scale. The accuracy is within 2% of the coating thickness. A special "U" electromagnet in the detector induces a flux in the part. The instrument responds to the reluctance of the path offered to the magnetic flux between the detector pole pieces. This reluctance is higher or lower depending upon the thickness of the nonmagnetic coating between the pole pieces and the magnetic base material. The meter shows this variation in reluctance as a direct indication of thickness.

Other units, such as the automatic "FS-200", are for automatically sorting small parts as to variations in size, hardness, and alloy composition, and for detecting defects.

ELIZABETH HARTNER

Testing the Tendency to Stress-Corrosion Cracking*

IN THIS investigation of the resistance to stress-corrosion cracking of aluminum-free and aluminum-containing structural steels, use was made of prolonged tensile tests at elevated temperatures. The tests were carried out in a boiling calcium-ammonium nitrate solution. The effects of loading, solution concentration, solution temperature, heat treatment and welding of the steels on stress-corrosion cracking are determined, together with the rates of fissure formation.

The method used is similar to the ordinary creep test with the exception that the bath of boiling calcium-ammonium nitrate supplies the heat as well as the corrosion medium. This solution consists of 60% crystallized $Ca(NO_3)_2$, H_2O and 4%

(Continued on p. 142)

*Digest of "Improving the Testing Method for Determining the Susceptibility of Steel to Stress-Corrosion Cracking", by Wilhelm Rädeker, *Stahl und Eisen*, Vol. 73, April 9, 1953, p. 485-492.

Case No. 61

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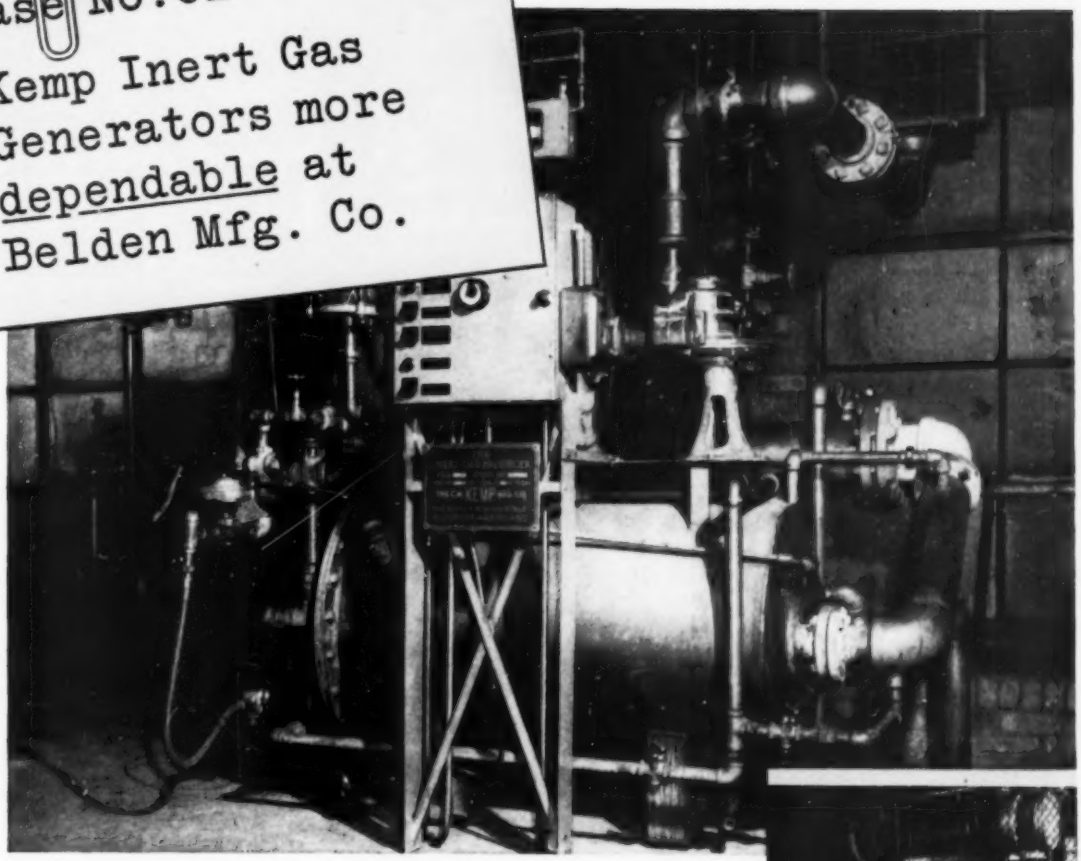

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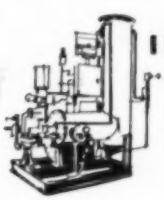

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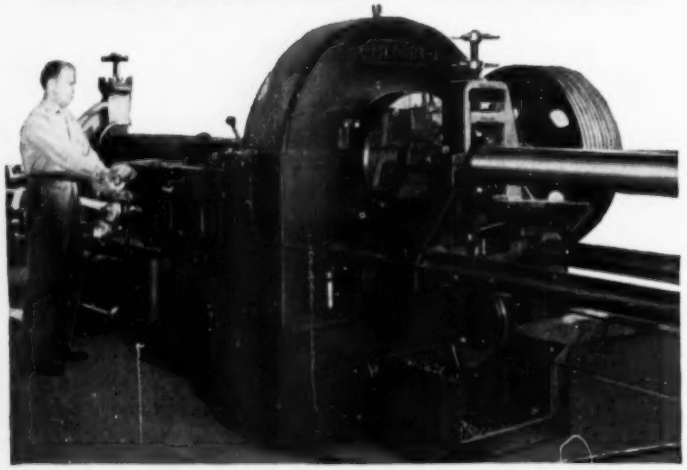

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Testing the Tendency to Stress-Corrosion Cracking

(Continued from p. 140)

NH_4NO_3. The specimens for the creep test bars were of either rectangular or circular cross section.

Lead was applied to the specimens by means of a tensile test machine equipped to hold the load constant for long periods, even when the specimen is elongated. Failure of the specimen was immediately indicated by a noticeable change in the action of the machine.

The authors point out that even though the load is held constant, the stress over the whole of the cross section does not remain constant after the cracks are formed but increases greatly with the decrease of the cross section after cracking has started. It was found impossible to measure the size of the cross section during the course of a test; therefore the actual stresses could not be calculated. The stresses acting on the original cross section are considered to be the most important when determining the onset of fissuring. The final stresses prevailing at the moment of cracking can be estimated by measuring the last cross section which actually carried the load. The first tests to establish the method were carried out with ordinary rather than aluminum-killed openhearth steels. Finally these results were compared with tests carried out with aluminum-treated steels.

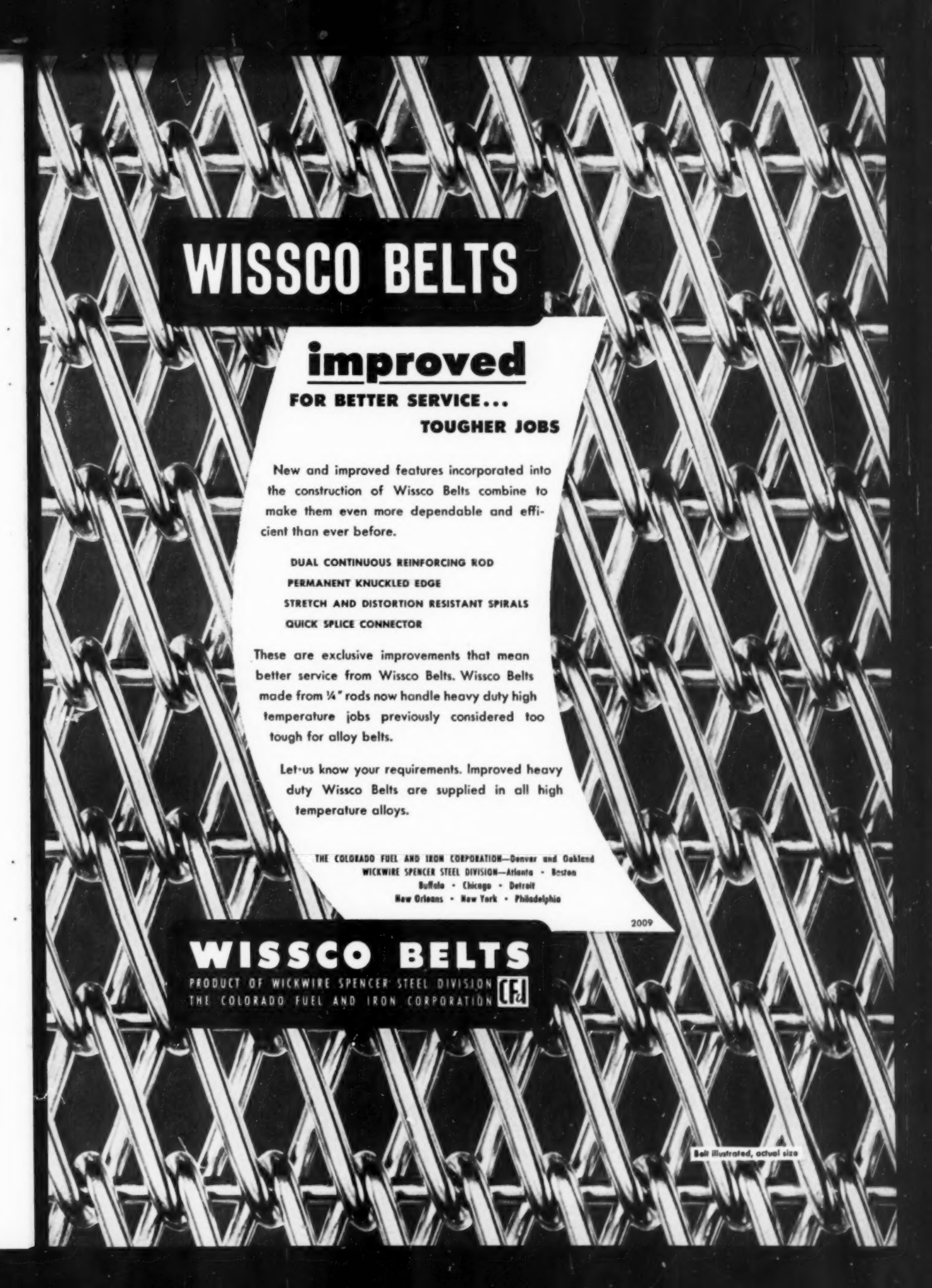
The authors claim that, with other testing methods, the value of individual tests was only statistical and that the results were badly scattered, whereas the method described in this paper does not have these disadvantages. The individual values are said to have a much greater significance; also the repetition of a large number of tests has shown that the results are reproducible and quickly obtained.

The observations reported are:

1. The endurance (time to fracture) was found to increase with decreasing load on the specimen.

2. When the endurance was plotted against the mechanical loading on a log-log scale, a straight line was not obtained. A large break in the curve was found to appear in the neighborhood of the yield point or

(Continued on p. 144)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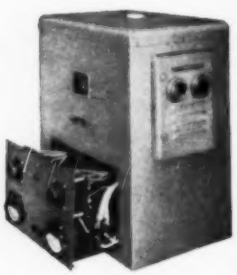

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Testing the Tendency to Stress-Corrosion Cracking

(Continued from p. 142)

elastic limit. The formation of cracks leading to the eventual fracture of the specimen was also found to occur under loads in the elastic range (below the yield point).

3. The sensitivities of the various steels to stress-corrosion cracking are shown by the relative positions of their log-log curves of endurance as a function of tensile loading.

4. The endurance of the specimens increased with decreasing solution concentration – the log-log plot is a straight line in this instance.

5. The endurance of the specimens increases with decreasing solution temperature.

6. The sensitivity of ordinary unalloyed steels to stress-corrosion cracking was considerably affected by heat treatment.

7. The crack sensitivity of aluminum-treated steels is high in the "overheated" condition (annealed at around 1920° F.); this sensitivity was considerably decreased by further annealing at 1380° F. It is suggested that the increase in sensitivity to stress-corrosion cracking is influenced by the precipitation of aluminum nitride.

8. The prolonged high-temperature tensile test described was also found to be suitable for the testing of welded specimens to determine their tendency to stress-corrosion cracking. It was found that weldments with low sensitivity to stress-corrosion cracking do exist. Tests carried out on some welded specimens resulted in fractures in the base material rather than the weld.

9. The investigations with steel specimens showed that an average rate of crack growth (rate of cracking) could be calculated.

Sixteen diagrams and photographs are used to illustrate the results of the actual investigations carried out using this new technique; however, there are no diagrams or photographs given to aid in the description of the test equipment.

A discussion follows the paper in which most of the remarks are confined to the results of the tests with little attention to the method used.

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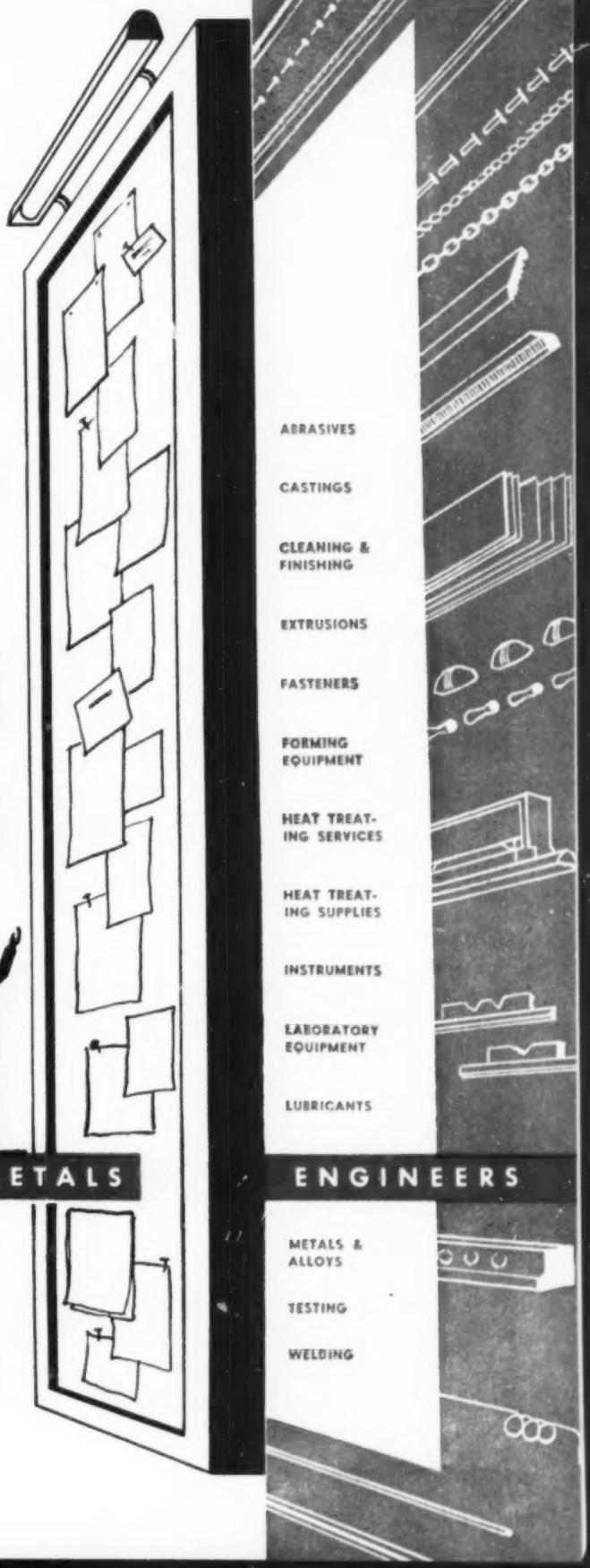

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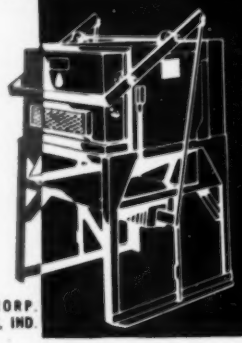

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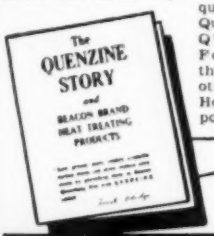

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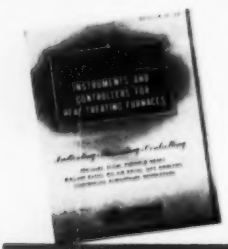

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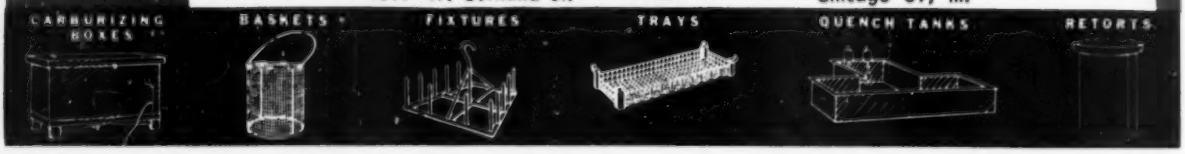

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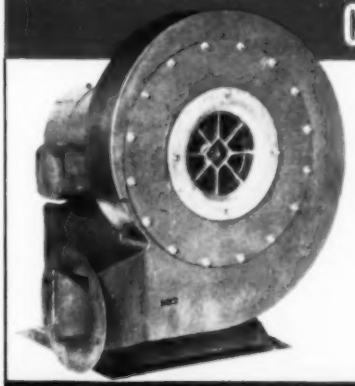

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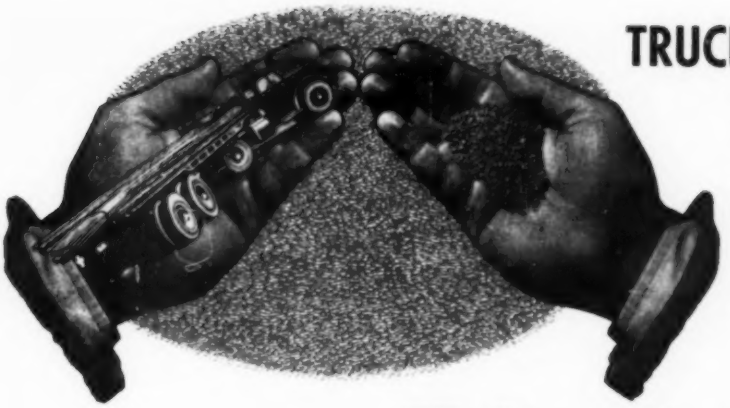

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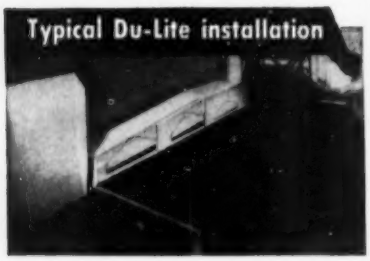

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the persuasive abrasive

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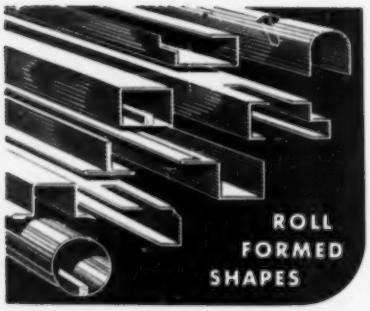

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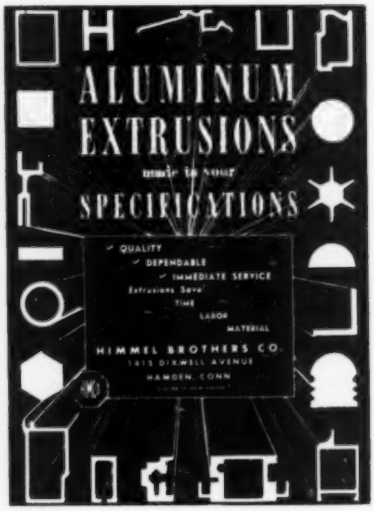

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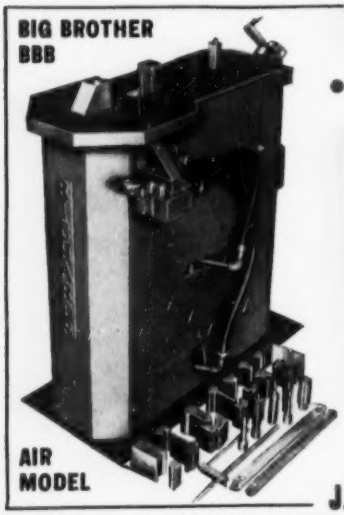

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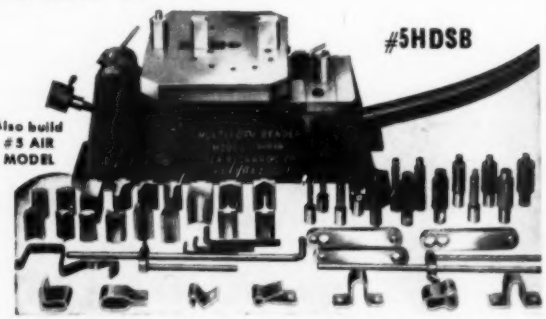

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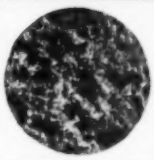	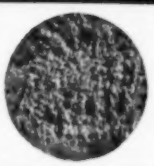

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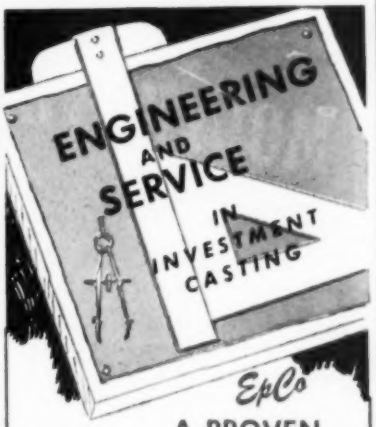

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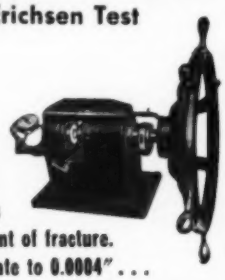
For Erichsen Test



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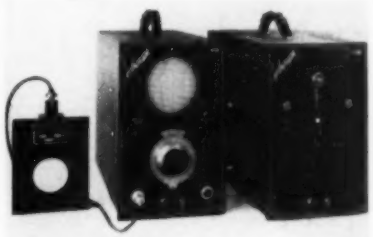

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"Non-destructive Testing and Measuring Instruments"

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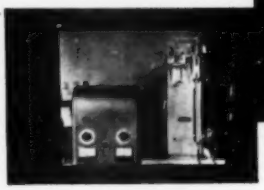

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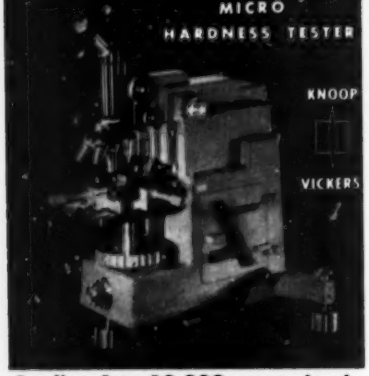

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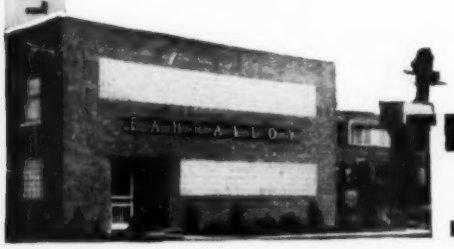

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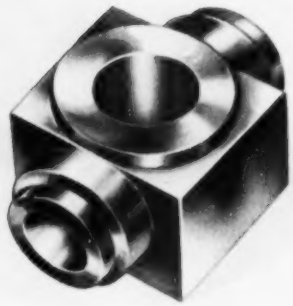

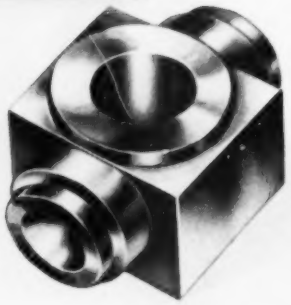

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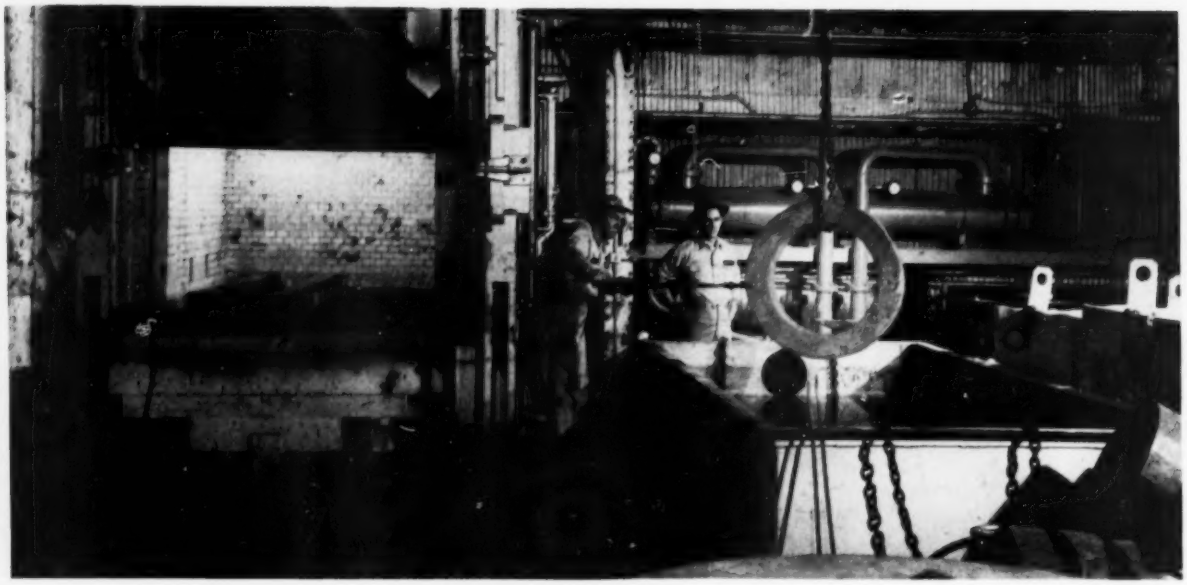

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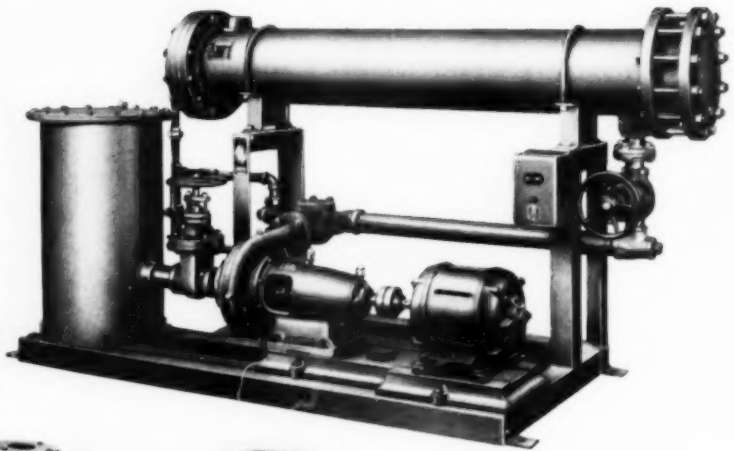

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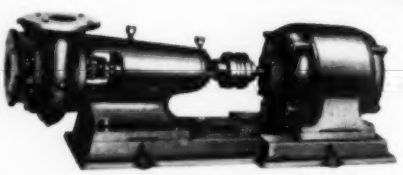

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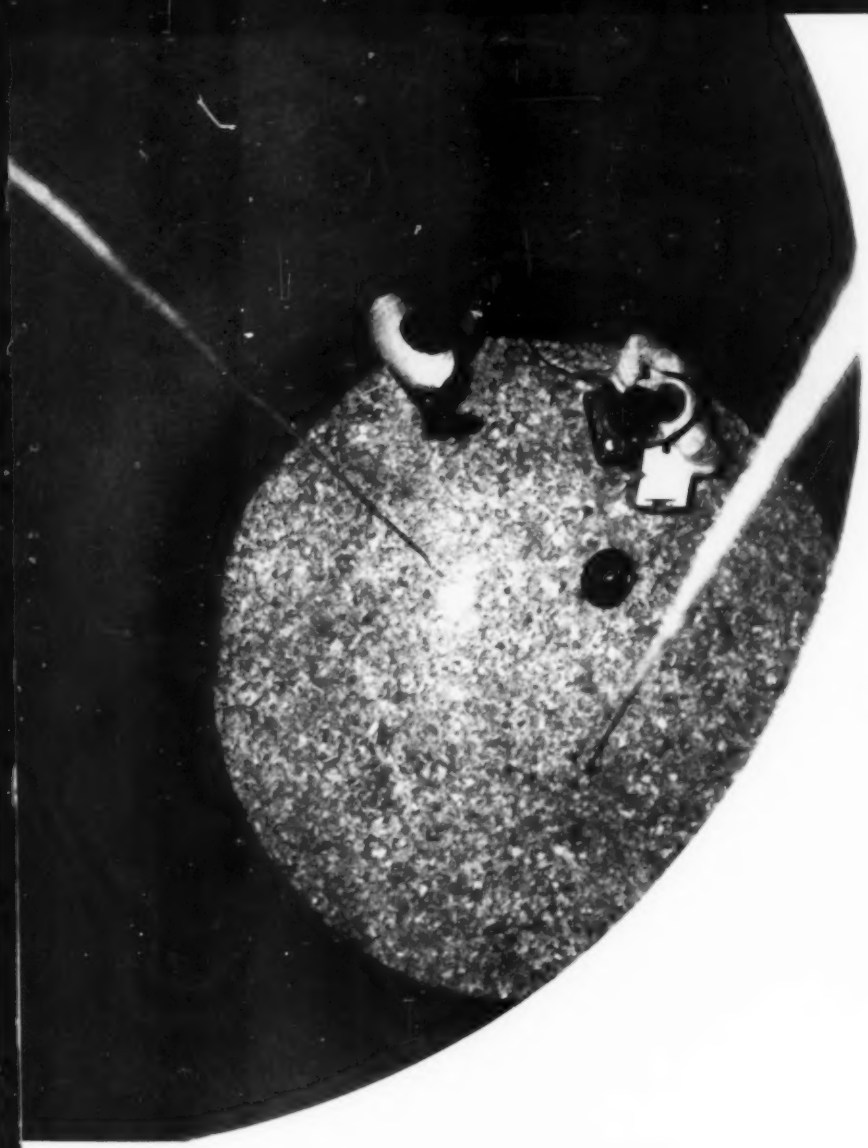


Measurement of Metal Thickness of Pulp Digester Made From Interior

By PETER K. BLOCH
Vice-President
Branson Instruments, Inc.
Stamford, Conn.

Portable Ultrasonic Instruments*

INSTRUMENTS using the ultrasonic resonance method are now used extensively for thickness tests, laminer flaw detection, and for the determination of bonding between materials. The basic principles were adapted by General Motors Research Laboratory during the last war to the testing of hollow steel propeller blades. Because of the simplicity of the basic circuit, the ultrasonic resonance method lends itself quite well to the design of portable, battery-operated instruments.

Principles – The ultrasonic resonance principle depends upon two fundamental characteristics of sound waves:

First, they travel through metal at a velocity that is a function of its density and of its elastic constants. This velocity is not appreciably influenced by wide variations in temperature, and is essentially independent of chemical composition, heat treatment, internal stresses, and the electrical or magnetic properties of the metal.

Second, sound waves are reflected by interfaces separating two materials, such as metal and water, that have different acoustical impedances. Standing waves can be set up within

*Presented at a Meeting of the Society for Nondestructive Testing at the Western Metal Congress, Los Angeles, March 1953.

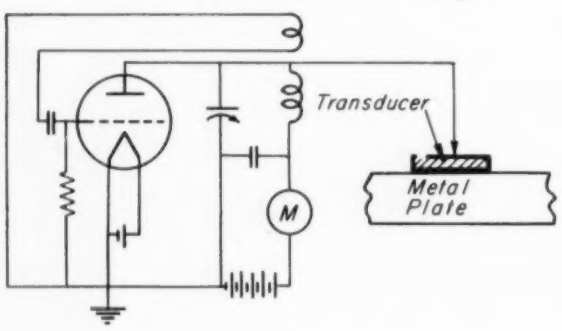
the wall of a pipe, or within a metal plate, just as standing waves are set up within the air column of an organ pipe. The frequency of the standing waves depends upon the thickness of the material and the velocity of sound in the material, just as the frequency of the organ pipe depends upon its length and the velocity of sound in air.

All these, as well as the equation which states the fundamental frequency at which thickness resonance occurs, are old and well-known facts from classical physics. The modern testing instruments perform two functions – the transmission of sound waves of known frequencies into the material and the detection of the presence of standing waves. The circuit of the instrument, shown in Fig. 1, is that of a variable-range self-excited oscillator which generates an alternating voltage for a piezo-electric transducer. The transducer transmits ultrasonic waves into the material through a thin film of oil or other coupling fluid.

If the oscillator is tuned to an integral multiple of the fundamental frequency transmitted into the material, there will be a sharp increase in the amplitude of the vibration in the part of the wall directly under the crystal. This resonant condition causes an increase in the energy dissipated. The effect on the oscillator is the same as adding a resistance across the inductance-capacitance circuit, and a sharp increase will result in the plate current (indicated on the meter "M", Fig. 1) of the oscillator.

The increase in oscillator plate current due to thickness resonance may exceed 100% under ideal conditions. Under many practical conditions the change in plate current at resonance may be only a fraction of 1%. Increased sensitivity over the circuit in Fig. 1 is obtained by frequency-modulation and amplification.

Fig. 1 – Basic Circuit for Ultrasonic Resonance Thickness Gage



In the "Audigage" instruments the oscillator is frequency-modulated over a relatively small frequency increment, at an audio rate. Thickness resonance in the material is indicated on a meter, and on headphones. By using harmonic frequencies in addition to the fundamental frequency, it is possible to cover a 200-to-1 thickness range with a 3-to-1 tuning range.

Other types of ultrasonic testing instruments are frequency-modulated over a 2-to-1 frequency range, and apply the output to a cathode-ray oscilloscope.

In most electro-mechanical instruments, the most important component is the transducer. The ultrasonic transducer uses a piezo-electric material, such as quartz, which produces mechanical wave motion when connected to an alternating electrical source. Ceramic piezo-electric materials such as barium titanate have shown considerable promise for use with ultrasonic resonance testing. Transducers used for resonance testing are driven over a relatively wide frequency range, which is below the natural frequency of the transducer. The transducer is rigidly cemented to a suitable plastic mount, for mechanical support and to eliminate "spurious" resonances which appear in the transducer itself.

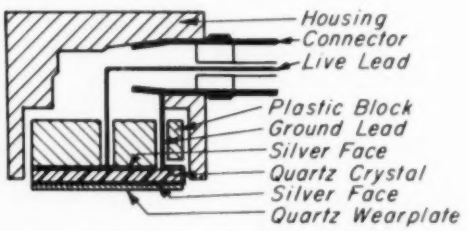


Fig. 2 – Mounting for Standard Flat Crystal

The standard flat crystal mounting is shown in Fig. 2. The quartz crystal is silver plated on both sides. The silver plating on the face is protected with an abrasion resistant plastic coating. Where abrasion is severe, the silver-plated quartz crystal is protected by a quartz wearplate. The sensitivity of composite crystals consisting of an active quartz crystal and a quartz wearplate is approximately equivalent to single crystals.

The transducer is normally mounted in a small holder, and held by hand. A gimbal mounting has been used very successfully for applications where the transducer or the work has to be moved continuously, especially over irregular surfaces. A permanent magnet fix-

(Continued on page 164)

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Portable Ultrasonic Instruments

(Starts on p. 161)

ture and arm can also be used on the standard crystal mounting, to hold the assembly in place in inaccessible locations.

Flat crystals are used on surfaces with a radius of curvature of over 6 in. without much loss in sensitivity compared to the same crystal on a flat surface, providing a suitable viscous coupling liquid is used between the crystal and the work. Crystals also are cut to fit practically any desired curvature and result in substantially better performance for applications on small pipe.

Uses – One of the most important applications for portable resonance instruments has been maintenance inspection for extent of corrosion and erosion. Nondestructive thickness measurements are accepted by boiler inspectors and marine surveyors instead of the old method of drilling and plugging test holes.

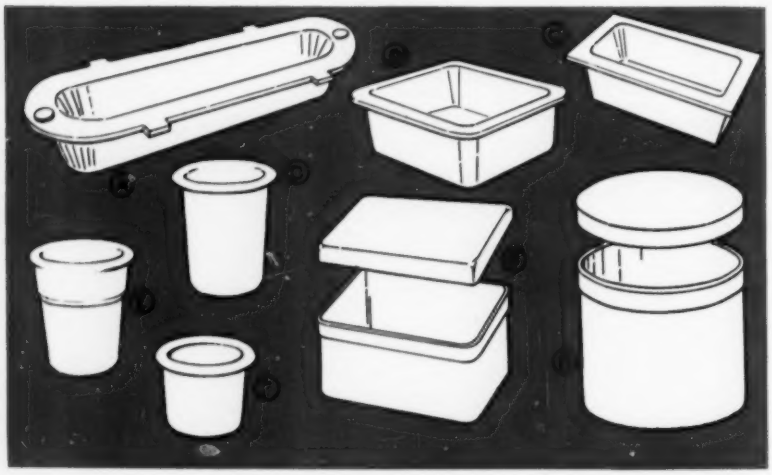
The standard Audigage thickness tester used generally for corrosion inspection has a frequency range of 0.65 to 2.0 million cycles and a thickness range of 1/16 to 12.0 in. of steel. Measurements are within 3% of actual thickness on rough surfaces, 1% on relatively smooth surfaces. One man can operate the instrument, carrying it in a harness.

A typical application is in the pulp industry, where large pressure vessels or digesters convert wood chips to pulp (shown in the lead illustration on p. 161). Digesters, approximately 10 ft. diameter and 30 ft. high, are operated under 125 to 150 lb. pressure. Steel thickness for the required bursting strength is approximately 0.75 in. Because of severe corrosion and erosion, they are actually built much thicker – up to 2 in. thick. Corrosion rates vary widely within the industry, and even within digesters in a single plant. Most sulphate digesters are now being checked periodically. Approximately 100 to 200 corrosion measurements are taken on each digester during each inspection. Sequential readings taken at 6-month or one-year intervals in the same digester in the same location are now being analyzed by means of computing machines in order to determine the process variables which may be influencing corrosion rates. It was found that the largest error in measurements was due to variations in the exact location of the transducer for this test. Some mills weld studs to the insides of the digester, and use long chains with washers at 2-ft. intervals, to locate the crystal exactly. The inside diameter of the washer is made to fit the outside diameter of the crystal.

Corrosion inspection is of critical importance in oil refineries and chemical plants, because of high temperatures and pressures, and the volatile nature of the product. High-pressure piping is frequently attacked by eccentric erosion, both in straight sections and on bends.

High accuracy is sometimes required in the inspection of manufactured materials. For example, it was necessary to measure the wall thickness of rectangular wave guides for radar equipment within 0.0002 in.,

(Continued on p. 166)



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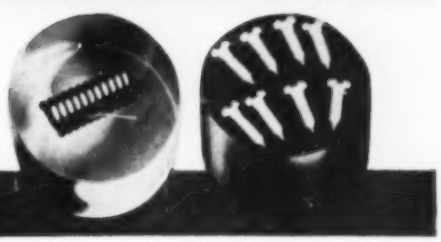

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Portable Ultrasonic Instruments

(Starts on p. 161)

or less than ½% of the actual wall.

The Audigage ultrasonic micrometer was developed for applications of this type. The instruments have a relatively narrow frequency range so that the resonance frequency can be determined accurately. Transducers, frequency range, and other components are selected for maximum signal sharpness and resolution. Scales and coils are made specifically for each application. These components are removable from the outside of the instrument, so that other ranges can easily be substituted.

Ultrasonic resonance instruments have been used very successfully for the detection of laminar flaws. Minimum flaw area, across the path of the beam, must be approximately one half of the effective transducer area. Resonance instruments are therefore incapable of detecting some of the very small discontinuities found with ultrasonic pulse testing instruments. Resonance instruments are particularly suitable for testing large structures, and field testing at isolated locations.

Lamination in steel plate or pipe can be found with the standard thickness tester. Often, an automatic operation can be developed around the instrument. Full-scale meter deflection is obtained on sound metal, whereas there is no deflection over the lamination. Modulation is sufficiently wide so that normal variations do not detune the instrument.

Past progress in ultrasonic testing was sparked by test engineers in industry who were dissatisfied with existing methods and equipment, formulated the need for improvements, and worked patiently but persistently with the instrument manufacturer. Future improvements of ultrasonic test instruments will continue to depend on the requirements of industrial users. Specialized instruments will be developed for specific applications wherever the needs of the user are sufficiently important. Instruments can become smaller or more elaborate, more specialized or more versatile, more accurate, more sensitive, and more automatic. The direction of future development depends on the needs of industry.

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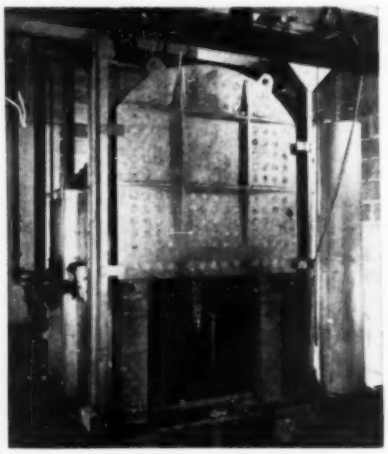
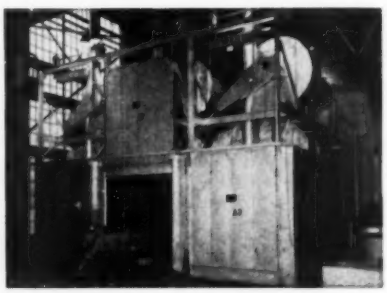


This car-type annealing furnace is an example of the heat treating furnaces designed and engineered by the Carl-Mayer Corp. This particular car bottom furnace was designed for the heat treatment of chain up to 2000°F. at Cleveland Chain & Mfg. Co. We also build furnaces for other uses, including aluminum and magnesium heat treating.

● ● ●



This battery of three aging ovens incorporates direct gas-fired recirculating air heating systems and other features which contribute to uniformity and faster, more economical production in a large aluminum company.

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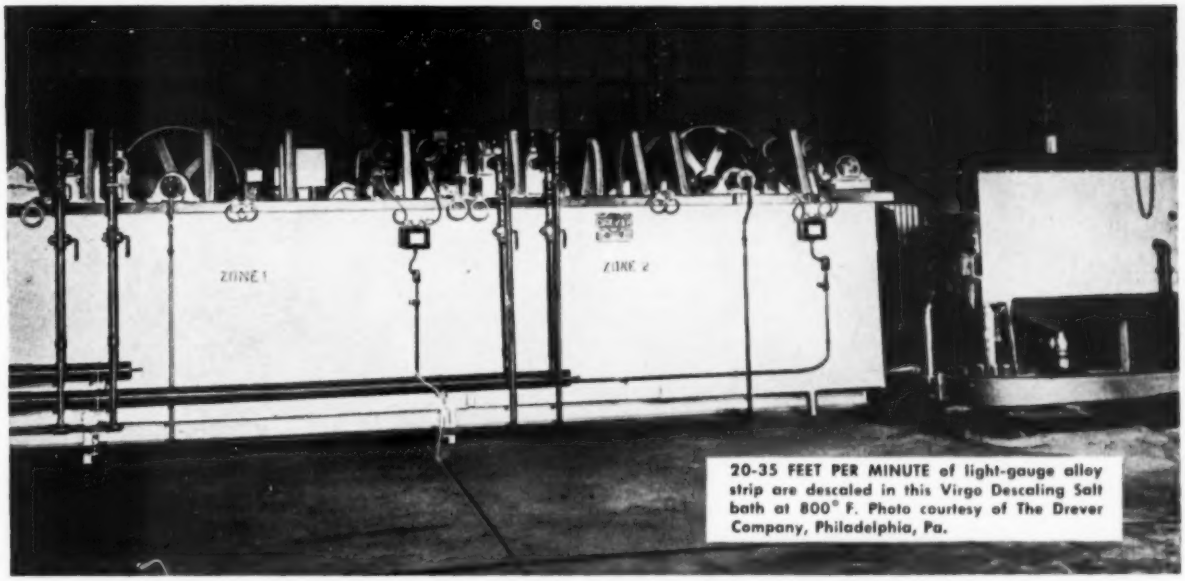

20-35 FEET PER MINUTE of light-gauge alloy strip are descaled in this Virgo Descaling Salt bath at 800° F. Photo courtesy of The Drever Company, Philadelphia, Pa.

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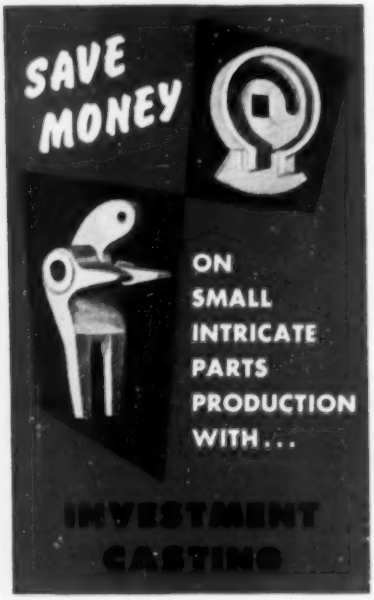

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Automation

(Continued from p. 70)

Capable of remarkable savings in unit costs over large production lots, automation for the smaller plant presents complex problems of design and economics. Combining similar groups of operations into a single machine is a good way to start.

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How to adapt the inherent capabilities of the electronic tube to control metal finishing operations and final assembly is one unanswered question which would appear to postpone the ultimate evolution of the automatic factory as it has been so enthusiastically portrayed by the "electronikers".

In any event, progress will be gradual and evolutionary. It would be sheer folly to discard the enormous capital investment in present industrial equipment merely to achieve the workerless plant, to say nothing of the sociological implications of such a revolution.

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(Continued on p. 170)

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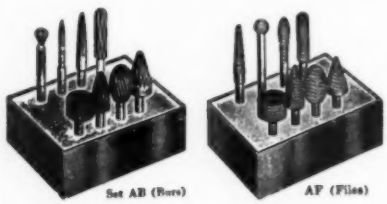

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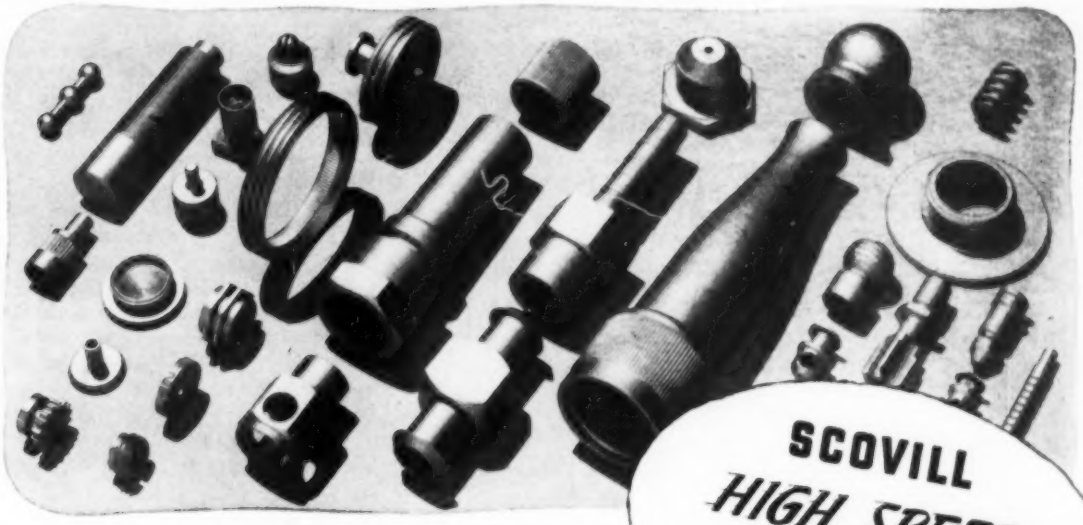

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Automation

(Bibliography starts on p. 168)

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(Continued on p. 172)

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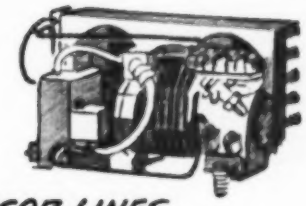

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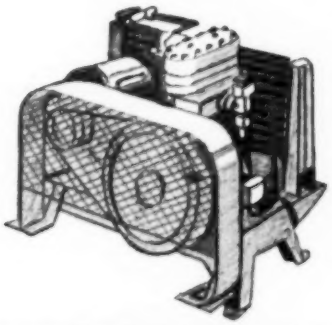

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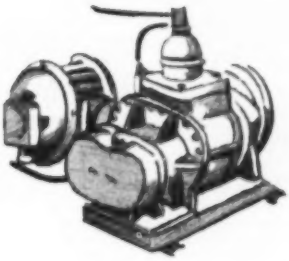

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Automation

(Bibliography cont. from p. 170)

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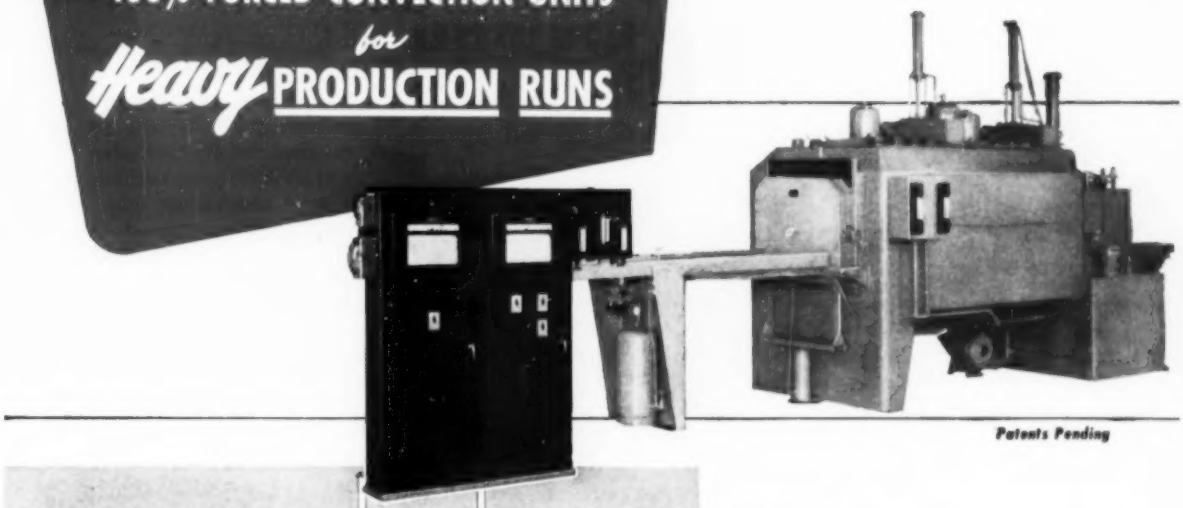

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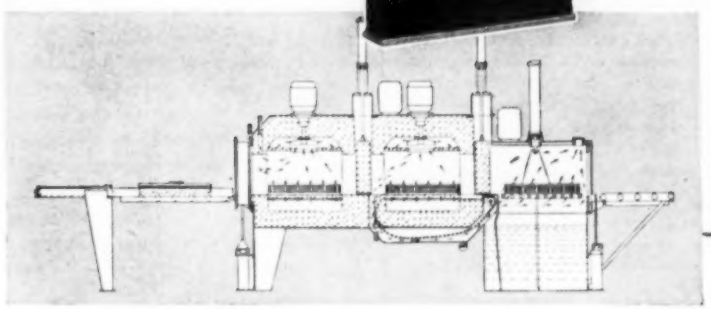

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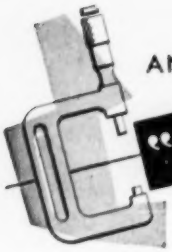

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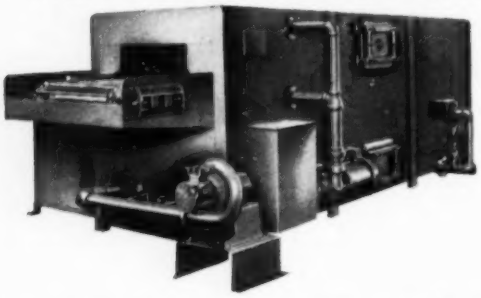

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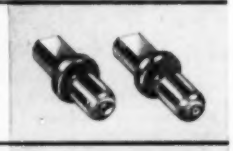

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CLARK

German Boron Steels

(Starts on p. 101)

tensile properties are closely similar, and the impact strengths somewhat superior.

Subject to the limitations of laboratory work on only one to three small heats of each type of steel, and without any systematic information on machinability and other fabrication qualities or on endurance, a few general observations may be made about steels for through hardening:

1. The increased hardenability caused by an addition of boron affects the mechanical properties in proportion as the martensite is increased in the microstructure within a greater depth from the surface. For this reason the notched-bar impact strength was higher at the higher tensile strength levels achieved in thinner sections.

2. Improvement in mechanical properties due to increased hardenability is not so great for the boron-treated manganese-silicon steel that their substitution for chromium steels can be recommended. Nevertheless, the utilization of the boron effect on this steel could reduce the manganese and silicon contents to about 1% each. Production economy, however, would be the deciding factor rather than the saving of alloy.

3. Chromium conservation by a boron addition seems possible with the simple chromium steels investigated, in an amount depending upon the type and alloy composition, and possibly coming to about 50 points or 10 lb. chromium per ton.

4. When considering the substitution of boron for molybdenum in chromium-molybdenum heat treating steels, it must be considered that molybdenum has some characteristic influences such as improving the stability during tempering – that is to say, in avoiding temper brittleness – and also that the toughness of properly heat treated steels is essentially improved. According to the evidence at hand, about 15 points of molybdenum may conditionally be replaced by boron in steels which otherwise would contain 0.25 to 0.30% Mo. Practically, however, this conclusion is mainly of academic interest in Germany because of our production of substitute vanadium steels free of molybdenum.

(Continued on p. 176)

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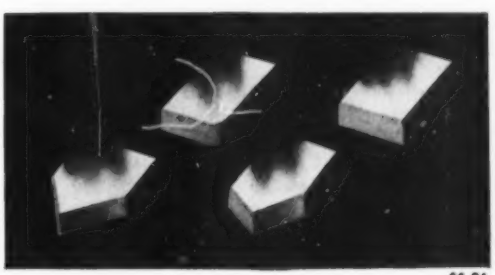

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German Investigations on Boron Steels

(Starts on p. 101)

5. Since vanadium is added to chromium-vanadium steels not merely to improve hardenability, its replacement by boron falls somewhat outside the target area of the present investigation. If the object is to increase the yield strength ratio through increased depth hardening, boron is able to exert the same effect as about 0.10% V. If the object is to increase the tempering stability with vanadium, substitution of boron is not possible.

SUMMARY AND CONCLUSIONS

Carburizing steels represent the class wherein there is most chance for conservation of elements. In appraising the possibilities Americans must remember that German standards contain but few steels instead of the wealth of varieties available in the United States; also that German carburizing steels contain no molybdenum. Investigations show that about 14 lb. of chromium plus nickel can be saved per ton of steel by treatment with boron, as in the replacement of the present standard 15 Cr Ni 6 with a steel like No. 5, with the same chromium (1.55% – high by American ideas) but with nickel cut almost in half. We have as yet very little information about the fabrication response and service performance of the substitute steel.

Heat treatable steels represent a less fertile field for alloy conservation. In German practice, the steels containing much nickel are used for massive parts which need a very deep hardening steel – and boron is intrinsically a shallow hardener. Consequently, the problem is the economical conservation of alloys other than nickel

With respect to the low-alloy heat treating steels, the boron-treated varieties are not unqualifiedly the equal of others containing 50 to 60 points more alloy. The boron addition was neither able to produce properties in manganese-silicon steels equal to those of chromium steels with higher hardenability, nor to replace molybdenum or vanadium

(Continued on p. 178)

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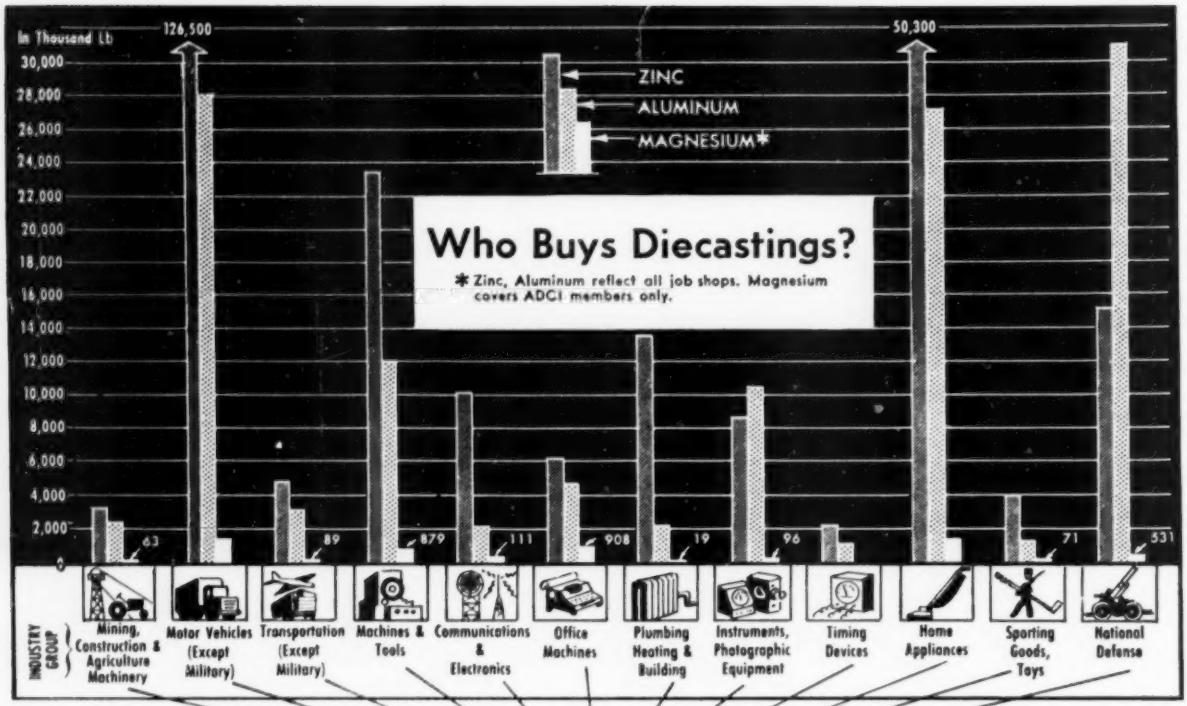

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these industries do!

Applications of zinc base die castings are so varied and widespread, it would be almost impossible for anyone to go through an ordinary day's routine of living without using—directly or indirectly—a large number of devices, appliances and services in which zinc alloy die castings form essential parts. The chart above, which shows sales by job shop die casters in 1952, tells its own story. More significant, perhaps, is that these sales were nearly six times the value of sales in 1936. Even considering rising costs and prices during the 16-year period, this is a remarkable record, and is representative of the entire die casting industry.

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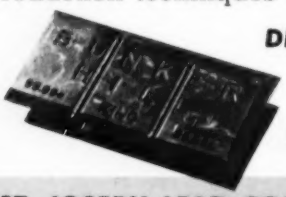

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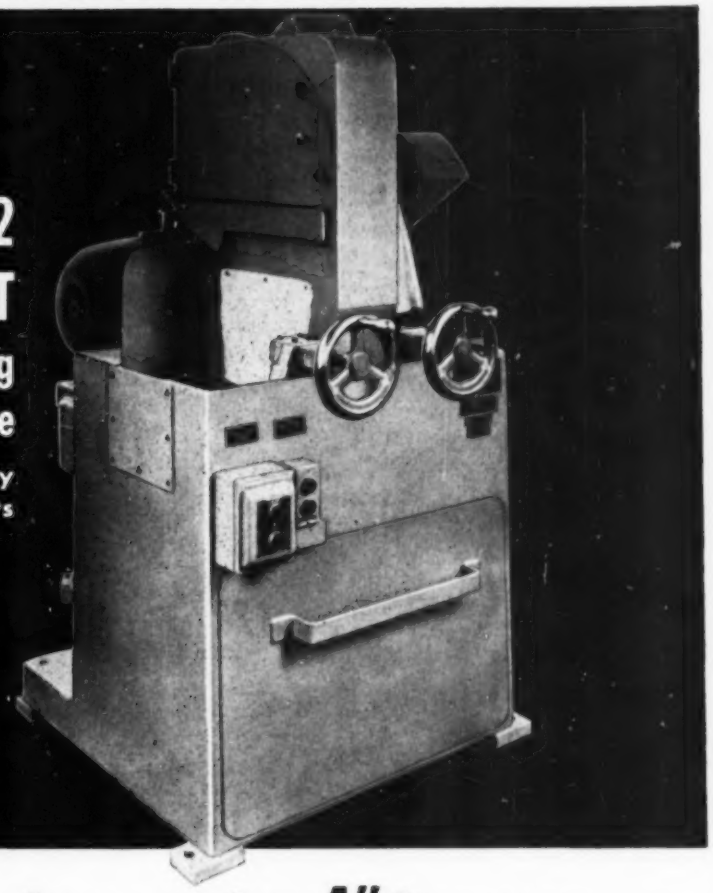

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German Investigations on Boron Steels

(Starts on p. 101)

whenever stability during tempering (freedom from temper brittleness) or strength at elevated temperature is the criterion.

A boron-treated chromium steel containing 0.41% C and 1.0% Cr (a high-carbon variety of standard steel 34 Cr 4) has been tested for screw machine parts as a replacement for chromium-vanadium steel (0.42% C, 1.5% Cr, 0.10% V, or 0.50% C, 1.0% Cr and 0.10% V) or replacing a chromium-molybdenum steel with 0.42% C, 1.0% Cr and 0.20% Mo. This steel is also being used as a replacement for a straight chromium steel for certain die forgings.

Observations up to the present have shown that such an exchange exacts no penalty either with respect to tensile properties (including fatigue strength) or with respect to machinability.

A general conclusion is that the conventional German practices in the use of through hardening steels give little chance for alloy savings by boron treatment of the alloys. Its use in this class of material must therefore rest on production economies other than the first cost of the manganese, chromium or vanadium which might be saved.

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Role of History in Evaluating Metals

(Continued from p. 88)

papers on the properties of crystals such as Elam on the "Destruction of Metal Crystals" in 1935, demonstrate the importance of associated sciences in the study of materials.

Timoshenko concludes his book by carrying the theory of elasticity to the year 1950. In the meantime two instrumentalities have made their appearance in the world. One is the combustion turbine, which requires materials resistant to high temperature, high stress, and high speed. The other is the navigation of the air at supersonic speed and high altitude. We now have the problems of thermal shock and resistance of materials and structures to high and low temperatures and under rapidly changing conditions. Even an amazing third should be added – atomic energy – which puts a premium on the nuclear properties of the materials of construction.

For all these we need tremendous quantities of new engineering data and this places the emphasis on the need for the development of new methods of test and much experimentation before a foundation can be laid for a theoretical and basic generalization. Sandwich and composite construction needs the development of new elastic theory.

Environment is demonstrated to be of overwhelming importance in the evaluation of materials. We are at the crossroads of a new era.

Oxygen in Iron-Vanadium Melts*

THE EFFECT of a deoxidizing element on the solubility and activity of oxygen in liquid iron determines the deoxidizing ability of the element. A previous estimate by Samarin and Polyakov indicated that vanadium is a weaker deoxidizer than is suggested in the calculations by John Chipman. Experimental data are given in the present paper.

(Continued on p. 180)

*Digest of "The Solubility and Activity of Oxygen in Iron-Vanadium Melts", by R. A. Karasev, A. Yu. Polyakov and A. M. Samarin, *Doklady Akademii Nauk S.S.S.R.*, Vol. 85, 1952, p. 1313-1316.

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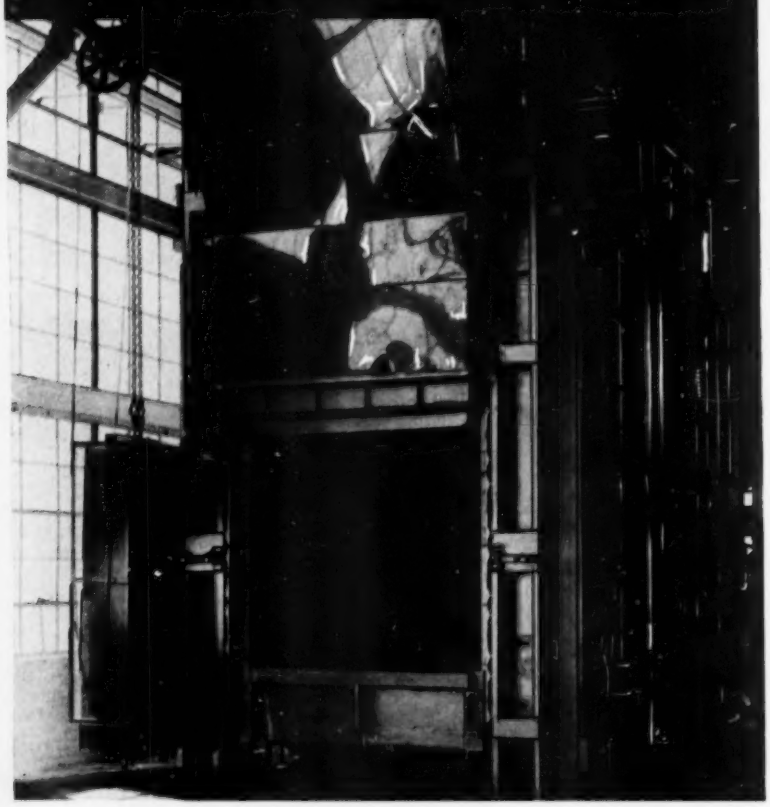

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Oxygen in Iron-Vanadium Melts

(Continued from p. 178)

The experimental method consisted in determining the equilibrium state when an iron-vanadium melt was held in contact with a gas phase containing controlled amounts of hydrogen and water vapor. The activity of oxygen in the metal was determined from the ratio of the partial pressures of water vapor and hydrogen, and after solidification the equilibrium vanadium and oxygen contents of the metal were determined. Electrolytic iron and chemically pure vanadium trioxide were used in these experiments.

A typical deoxidation curve was gvien by a plot of the data on oxygen content versus vanadium content of the alloys for 2795° F. At 0.1% oxygen there was 0.1% vanadium; at 0.05% oxygen the vanadium was 0.3%, and the oxygen content leveled off at 0.02% as the vanadium increased to the largest values investigated, about 2.2%.

The substance produced by the reaction of the dissolved vanadium and oxygen depended on the vanadium content. Up to 0.2% vanadium it was a vanadium spinel, from 0.2 to 0.3% vanadium it was vanadium trioxide, and above 0.3% it was presumed to be V_2O_2, although only the trioxide was found by X-rays.

The activity of oxygen in liquid iron at 2795° F. was determined as a function of the vanadium content of the iron and was found to decrease with increase in vanadium. At 1.5% vanadium the activity was only 0.01 while the oxygen content was about 0.02%.

Deoxidation by vanadium was less effective at higher temperatures. Thus, 1.5% vanadium was in equilibrium with 0.02% oxygen at 2795° F., but was in equilibrium with 0.035% oxygen at 2910° F., and with 0.075% oxygen at 3090° F. Silicon is several times more effective than vanadium at 2910° F.

The data of Dastur and Chipman indicate a higher deoxidizing power of vanadium than does the present work. However, the authors could not accept these data as reliable since Dastur and Chipman employed a doubtful equation for the temperature dependence of the solubility of oxygen in liquid iron. A. G. Guy

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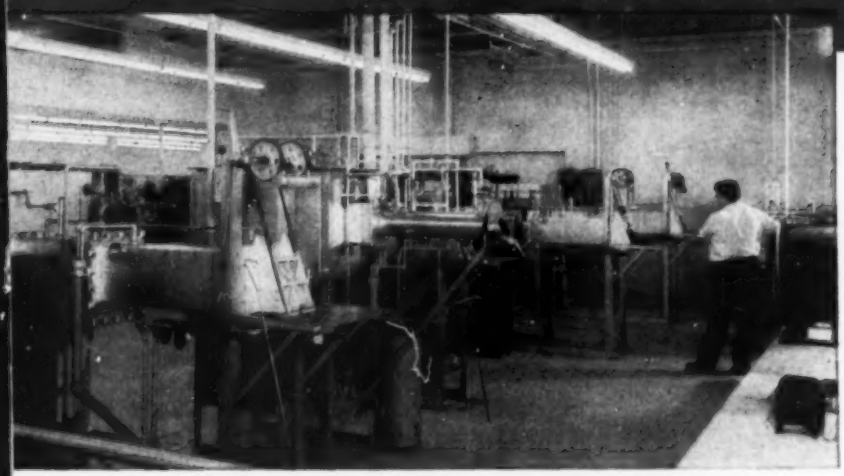

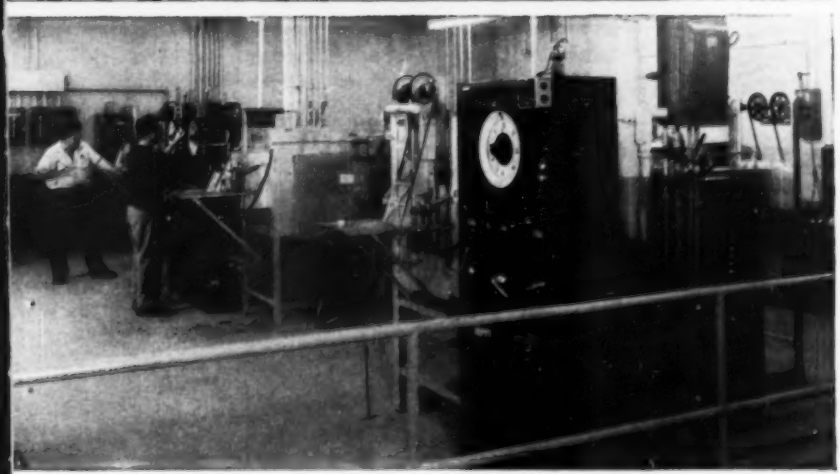

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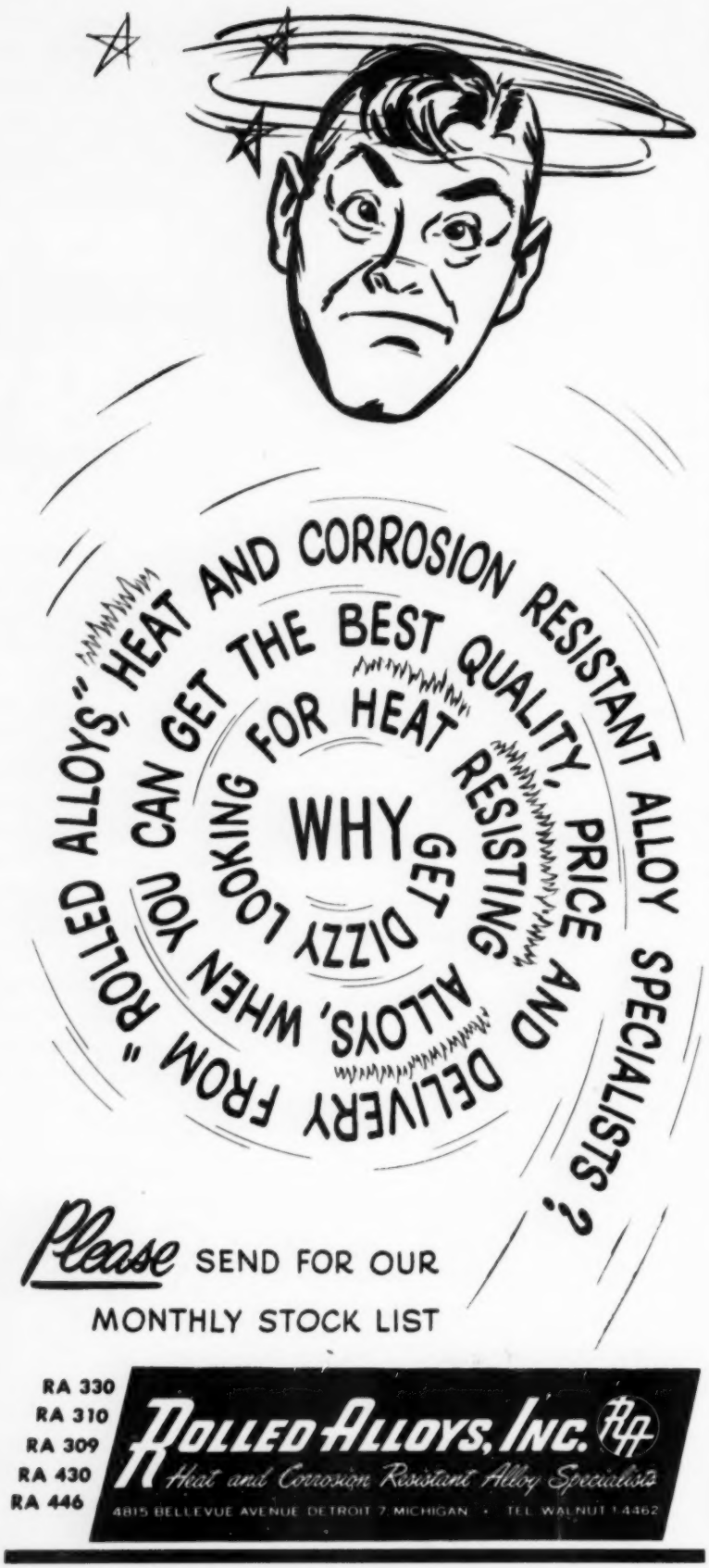
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Intracrystalline Voids in Magnesium Alloys*

THE AUTHOR states that extensive metallographic work on magnesium alloy castings revealed cavities having hexagonally shaped prisms in the central portions of many grains. These cavities were observed only in aluminum-containing alloys that had been solution heat treated — most commonly in Elektron AZ 91 (9.5 Al, 0.5 Zn, 0.3 Mn) and to a less extent in Elektron A 8 (8 Al, 0.5 Zn, 0.3 Mn). Some were produced in experimental magnesium-aluminum alloys containing 10 and 12% aluminum. Cavity formation varied with each melt of a given alloy, even when structures and analyses were almost identical. It was established, by inducing coarse precipitation in known crystallographic planes, that the hexagonal voids and the hexagonal lattice of the grains containing them had the same orientation.

The effects of time and temperature of solution treatment on cavity formation were investigated by using sand cast AZ 91 test bars of established susceptibility to cavity formation. Specimens were treated in a small air-circulating furnace and allowed to cool freely in air. After short times (5 or 10 hr.) at 790° F. (these treatments were preceded by heating for 5 hr. at 725° F. to prevent incipient melting at the higher temperature), the cavities were less sharply defined and smaller than for the normal treatment of 24 hr. at 790° F. "Normal" cavity formation occurred at this temperature after 15 to 40 hr. Longer times caused a decrease in number of cavities, only a few being found after 72 hr.

The effect of increasing temperature was similar to that of increasing time. No cavities were observed after a treatment of 24 hr. at 680° F., and only a few small ones after 24 hr. at 720° F.; solution was far from complete in both. Treatments at 750, 790 and 825° F. for 24 hr. gave "normal" cavity formation. After 24 hr. at 840° F., the number of cavities

(Continued on p. 184)

*Digest of "The Formation of Intracrystalline Voids in Solution-Treated Magnesium-Aluminium Alloys", by E. Lardner, *Journal* of the Institute of Metals, Vol. 81, May 1953, p. 439-442.

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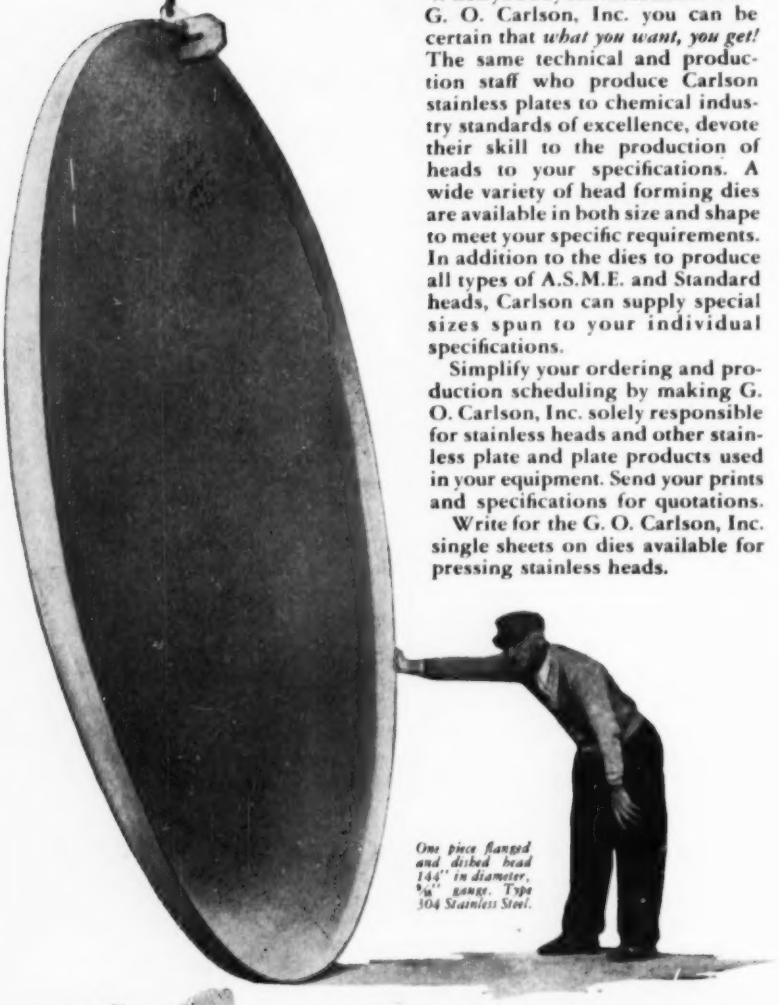

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Intracrystalline Voids in Magnesium Alloys

(Continued from p. 182)

had decreased considerably but their size increased. No cavities were found after a cyclic treatment of 5 hr. at 725° F., 16 hr. at 790° F., and 16 hr. at 840° F. These results show that cavity formation initially increased with the degree of solution, and subsequently decreased until finally no cavities were found.

Cavities already present could not be removed by subsequent heat treatments. Hence, the lessening tendency for cavities to form with prolonged solution treatment apparently was not attributable to the closing up of cavities that formed earlier. It seemed probable that the cavities were associated with a condition created by heat treatment ,but that their actual formation occurred during cooling. To investigate the effect of cooling rate, samples of the AZ 91 were solution treated (8 hr. at 725° F. followed by 16 hr. at 790° F.) and cooled in various ways. The times to cool from 790° F. to 210° F. ranged from a few seconds to 20 hr. Specimens that cooled in 1 hr. or less showed "normal" cavity formation. Two were furnace cooled in 6 and 20 hr., and these were similar to each other and showed very few cavities. However, the cavities in these lacked the characteristic sharp, straight outlines.

To investigate the effect of grain size, AZ 91 of known susceptibility to cavity formation was cast with different degrees of chill. Specimens having very fine grain showed no cavities after treatments of 4 to 24 hr. at 790° F. (solution was complete in about 6 hr.). Samples from sand cast test bars (intermediate grain size) showed "normal" cavity formation after 24 hr., while coarse-grained pieces showed no cavities after 24 or 48 hr. at 790° F. but many large ones after 48 hr. at 825° F. Cavitie; that occurred in solution treated vertical sections which were taken from a directionally solidified AZ 91 block having a highly chilled, fine-grained bottom portion were confined to the upper part of the sections where the structure resembled that of a sand cast bar.

Although AZ 91 would be ex-

(Continued on p. 186)

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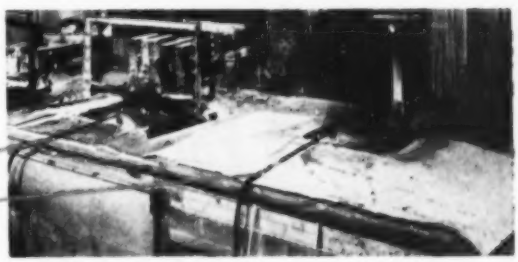

Even high-speed hardening baths up to 2300°F. are easily maintained neutral. At Commercial, both pre-heat and high heat are rectified daily to zero alkalinity. Rectification is at 1850°F. in the high heat, done either on idling time or when furnaces are being used for hardening high carbon, high chrome die steels. Salt is Park Pre-heat 117, and Park High Heat 175-S.

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Intracrystalline Voids in Magnesium Alloys

(Continued from p. 184)

pected to show a slight contraction on solution treatment, expansion occurred as often as contraction. The bars that expanded showed cavities; those that contracted did not.

The author suggests that cavity formation is connected with aluminum concentration gradients in the grains at the termination of the solution treatment. Such gradients could build up during the early stages of treatment and their elimination might require a much longer time than complete solution. On cooling, the concentration gradients could set up internal stresses within the crystals which, in conjunction with some other unknown factor, might cause the cavity formation. He also states that the formation of similar cavities by the diffusion of zinc out of brass is consistent with this hypothesis.

G. F. SAGER

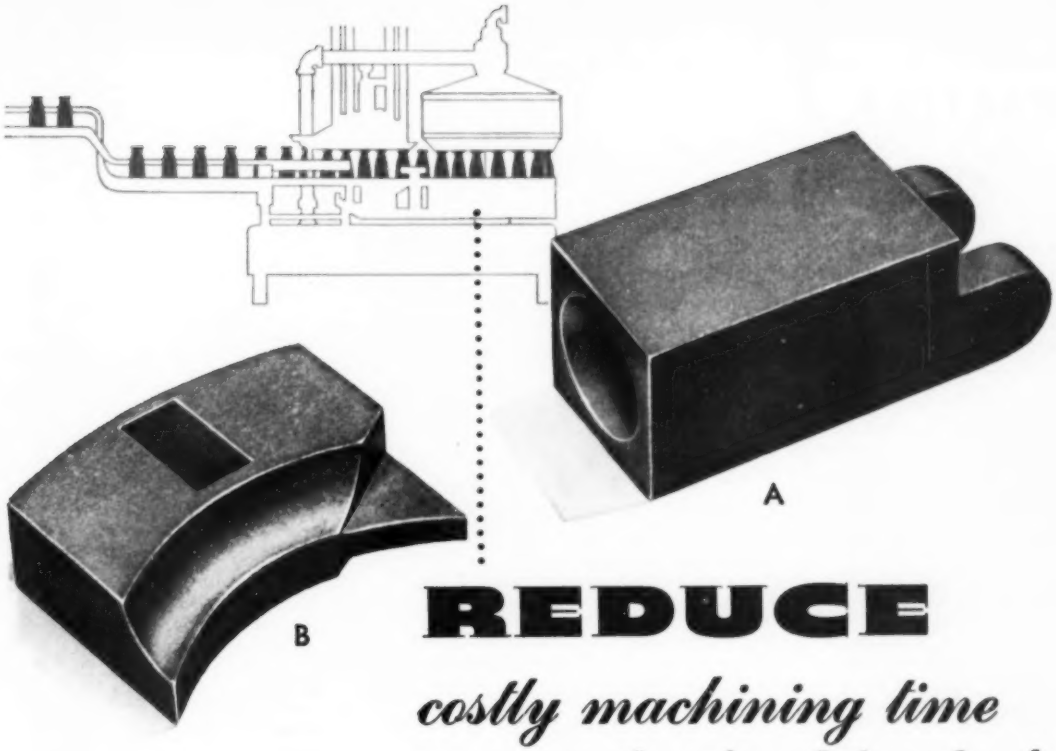
Production of Sound Castings*

INASMUCH as the final object of both papers is the production of sound and pressure-tight castings, they may well be considered together. While it is true that questions pertaining to the effect of gases in metals and the provision for economical and effective feeding of castings by means of risers are much to the fore these days, yet it appears that no apology is needed for drawing attention to recent contributions on this subject.

The value of Mr. Mantle's paper stems from the fact that the laboratory tests have been substantiated by regular foundry operation. Examples are given of two kinds of pressure castings made from the bronze of 5 Sn, 5 Pb, 5 Zn, 85 Cu that caused trouble by leaking at the junction of the heavy and light

(Continued on p. 188)

*Digest of "Nitrogen Degassing and Metal-Mold Reaction in the Production of Gun Metal Castings", by E. C. Mantle; and of "Insulating Feeders for Use With Copper Alloy Sand Castings", by R. A. Skinner and R. W. Ruddle; both papers from the Association of Bronze and Brass Founders, "Conference Proceedings Harrogate", June 1952, p. 11-22.



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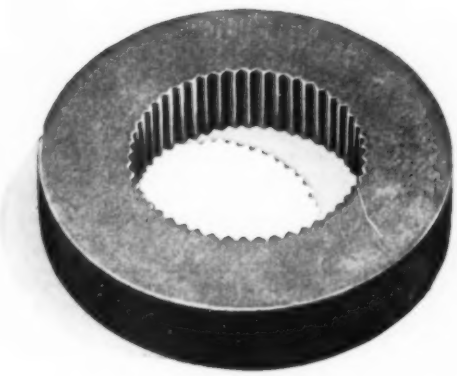

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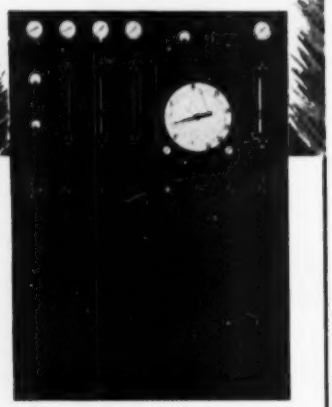

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Production of Sound Castings

(Continued from p. 186)

sections. In castings such as these valves, risers are very objectionable and often impractical. Leaky castings would appear occasionally despite the fact that no change had been made in the foundry procedure. The presence of gas in the metal was suspected as a possible cause of the leakers. In one run of 57 castings 13 were found faulty, and in another run of 84 there were 8 leakers. Both of these runs were from metal melted under ordinary foundry practice. For the subsequent productions half of each melt was treated by adding phosphor-copper in an amount equivalent to 0.08% phosphorus in the metal. Two test runs produced in this way gave 50 and 52 castings without any faulty items.

From this it would appear that the extra gas absorbed by the molten metal from the metal-mold reaction caused by the increase of the phosphorus content gave a metal of such internal structure as not to give leakers. However, a test of another item of heavier cross section made by the same treatment with phosphor-copper produced castings that leaked. When the gas was 3% by volume, it was found that 7 out of 14 castings leaked in one group and 10 out of 14 in another. Attention was then given to the gas content before the addition of the phosphor-copper, and it appeared as though presence of gas prior to the phosphorus addition canceled the good effect of the gas due to the metal-mold reaction.

Nitrogen was bubbled through the melts to sweep out the occluded gases (mostly hydrogen). This was done with 400-lb. melts of 85-5-5-5 bronze, the nitrogen being supplied from a cylinder equipped with a reducing valve to give 10 psi. pressure, the flow being regulated to 1.3 gal. per min. for 5 min. After degassing with nitrogen, enough phosphor-copper was added to give 0.05 to 0.08% phosphorus before the metal was poured. The dual treatment of degassing and then gassing by the metal-mold reaction gave a gas content of 1.2 to 1.6%, and each of the castings from two lots of 14

(Continued on p. 190)

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175	325	650	1200	1750
188	338	700	1250	1800
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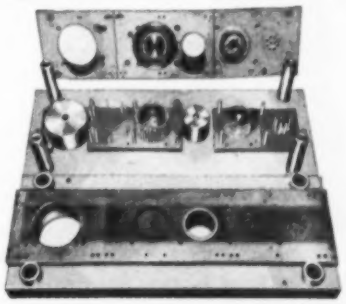
ANALYSES

	CROMOVAN	AIRVAN	INVARO
Carbon	1.60%	1.00%	.90%
Chromium	12.50%	5.25%	.50%
Vanadium	1.00%	.25%	.20%
Molybdenum	1.00%	1.15%	—
Manganese	—	—	1.15%
Tungsten	—	—	.50%



Generally speaking, CROMOVAN is intended for long production runs where hundreds of thousands or millions of pieces must be produced at minimum cost; AIRVAN for intermediate runs where toughness and high abrasion resistance are also requirements; INVARO, an oil hardening tool steel for all other general use.

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Production of Sound Castings

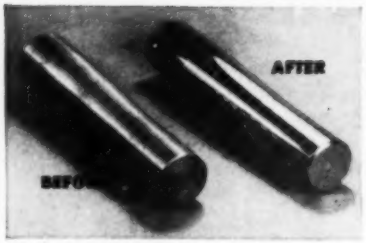
(Continued from p. 188)

produced by this technique was pressure-proof. It was admitted that the gas scavenging operation by means of nitrogen was rather crude. This being so, it would be worthwhile to give careful attention to the admittance of nitrogen through a porous plug, as described in the patent of E. Spire, so that the nitrogen enters the metal as fine bubbles and therefore has a better opportunity of sweeping out the hydrogen.

It is generally accepted today that all cast metals have a varying degree of porosity, and the problem is to avoid any connected passage between the voids that would enable gas to escape through the metal wall. In view of the careful tests worked out by Mr. Mantle, it would be wise to accept the presence of gas in the metal and attempt its control.

The article "Insulating Feeders for Use With Copper Alloy Sand Castings" deals with the comparative merits of exothermic feeders versus insulating feeders, and the possible benefit of covering the top of the risers. Data regarding time required for solidification of risers were obtained by the insertion of a thermocouple in the center of the riser. The tests were conducted with 85-5-5-5 bronze, high-tensile brass, and manganese bronze. What would seem to be a rather surprising result is that the greatest saving of metal for the riser was found with the closed plaster feeder, as opposed to the closed exothermic feeder. Both required much less metal than either the closed or open sand feeder. As a convincing example of this the authors cite the tests with an axle-box casting of manganese bronze weighing 53 lb. and measuirng 7¾x8¾x5½ in. The best results for ordinary risers were obtained by placing a single riser at one side of the casting. This riser was 12⅛x4½x 2½ in., weighed 41 lb. and resulted in a casting yield of 56%. When a gypsum-insulated feeder 3 in. diameter by 4⅛ in. long and weighing only 9 lb. was used, equally satisfactory results were obtained and the casting yield was 86%. Owing to the smaller amount of metal to be melted, with attendant reduction

(Continued on p. 192)



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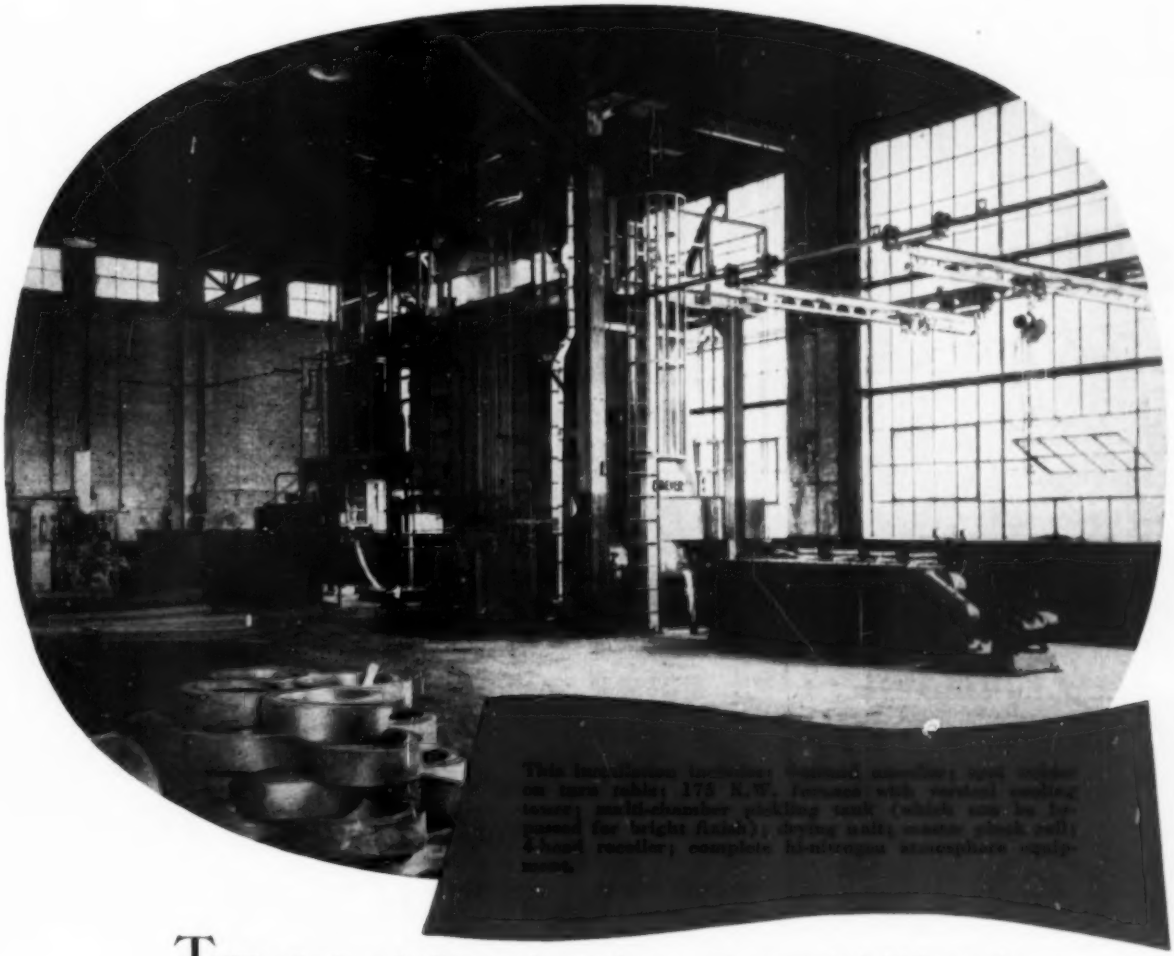

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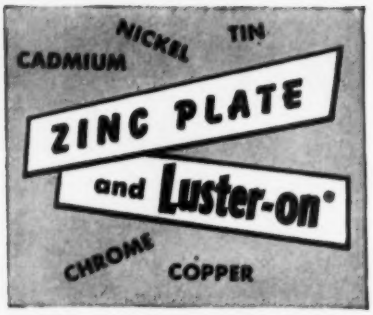

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Production of Sound Castings

(Continued from p. 190)

of melting costs and metal losses, the over-all cost of the casting was reduced by 7½%.

In the summary it is suggested that the methods discussed are unlikely to be economical for small castings having risers less than 2 in. diameter. However, for special castings where feeding is difficult, the use of either gypsum or exothermic materials is likely to prove very worthwhile. The use of such feeders would seem to be obligatory for large castings. H. J. ROAST

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(Continued on p. 194)

*Digest of "A New Method of Reduction for Iron Powders", by Heinrich Siepmann, *Stahl und Eisen*, Vol. 73, March 12, 1953, p. 360-364.

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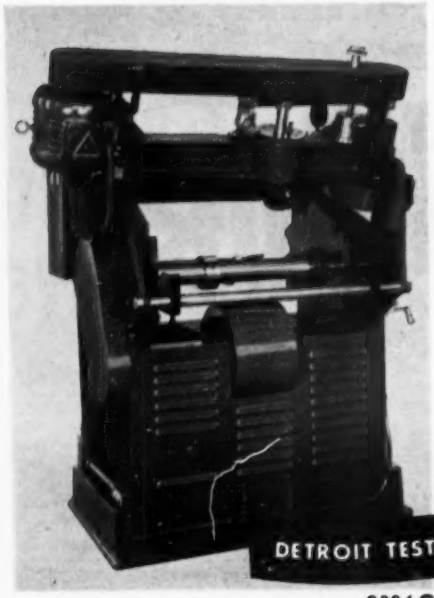

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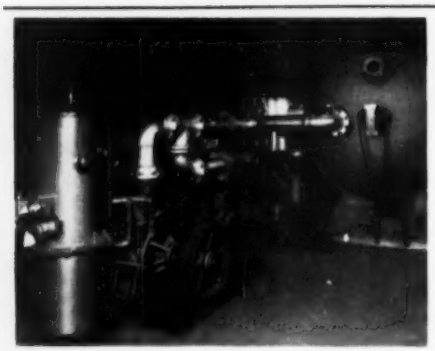

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THE NEW YORK AIR BRAKE COMPANY
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☐ Please send Bulletin V-51B describing the complete line of Kinney Vacuum Pumps.

Name
Company
Address
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Improved Method for Reduction of Iron Powders

(Continued from p. 192)

which causes a uniform and quick reaction to take place without sintering or coagulation. The porous wall is also made of iron powder to prevent the introduction of impurities. This material is very stable in the presence of reducing gases. Particle size, particle distribution and shape are important variables affecting favorable flow conditions.

Heating can be with gas or electricity. Cooling of the powder must be accomplished in a protective atmosphere, under exclusion of oxygen from the air. The powder should be classified as to particle size before treatment, if much variation is anticipated.

The treatment or reaction chamber consists of a cylindrical shell similar to a cupola closed by a hinged porous bottom. At completion of the reduction cycle, the powder drops through a funnel into the cooling chamber where it is transported by a conveyer belt into a large hopper.

The gas enters through the porous bottom and its force whirls the powder during the reducing reaction at about 1650° F. The rate of diffusion determines the velocity of reaction. Thermodynamic calculations suggest that 0.2 kw-hr. is needed to heat 2.2 lb. of powder to 1830° F.

The method of heating is important for the efficiency of the operation. The process can be continuous.

The amount of gas required per time element depends upon the oxygen content and speed of reaction. Tests have been conducted with a powder having an initial composition of 1.5 carbon, 0.10 silicon, 0.04 manganese, 0.09 phosphorus, 0.09 sulphur and 3% oxygen.

There is a critical temperature range above 1830° F. at which the powder becomes so viscous that the free movement of the particles ceases abruptly; therefore, temperature should be kept below this critical range. It has been possible to reduce the oxygen content from 3.0% to 0.2% in a pilot plant. The method seems to be advantageous for certain uses where economy is an important consideration. H. J. HEINE

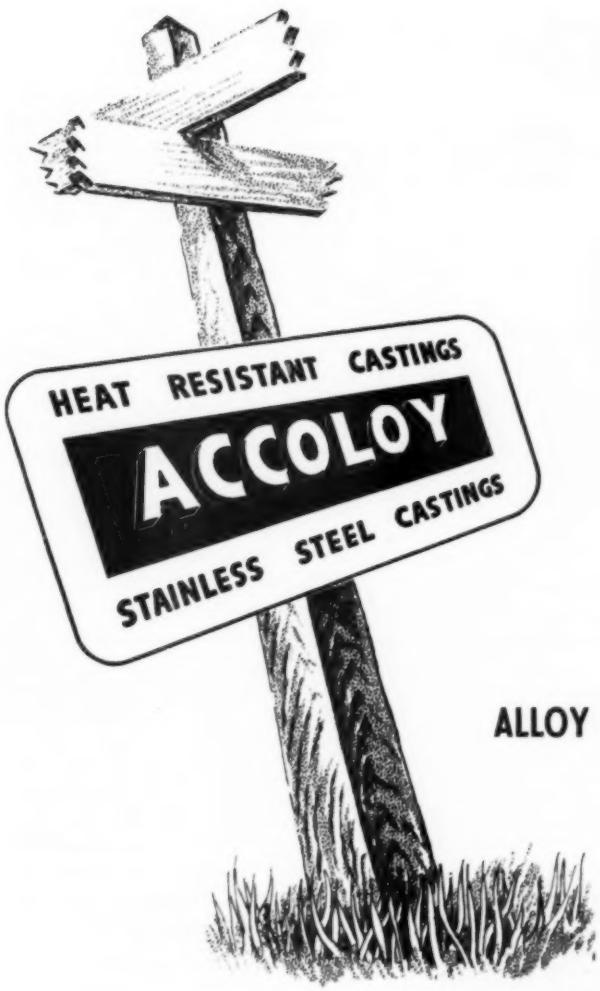
Guide Post to Profit . . .

Your profit for tomorrow will be decided by the work you produce today.

Keep every production line running with fewer breakdowns and less replacements by using ACCOLOY Heat and Corrosion Resistant Castings.

The improved designs, finer grain size, the close control of pouring and the multiple testing of each finished piece, all contribute to the longer service life of these castings.

As a manufacturer using trays and fixtures, carburizing boxes, salt pots, retorts, muffles or roller rails—*make an investment now that will keep you posted on the profit side of the ledger.*

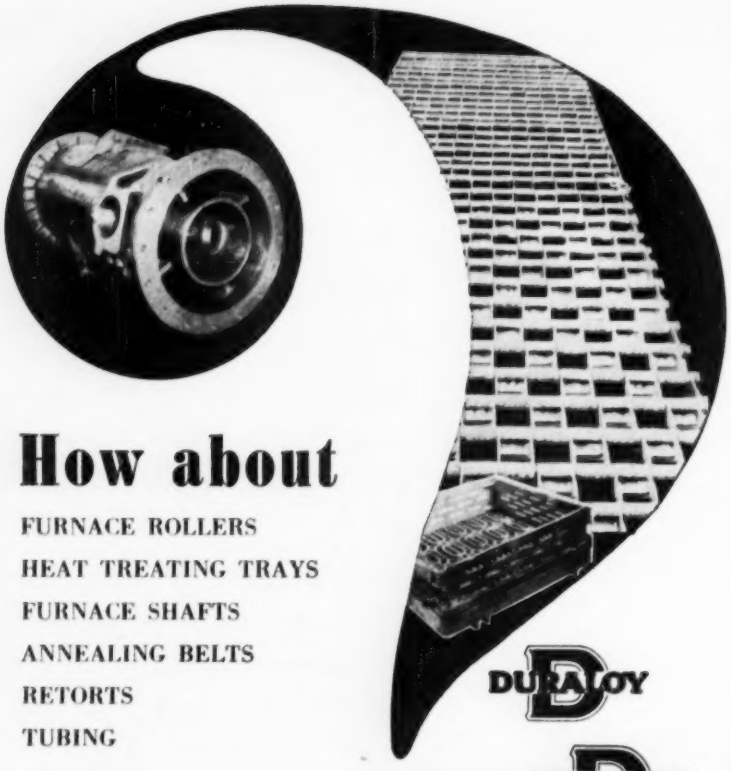


ALLOY ENGINEERING & CASTING COMPANY

ALLOY CASTING CO. (Div.)

CHAMPAIGN • ILLINOIS

ENGINEERS AND PRODUCERS OF HEAT AND CORROSION RESISTANT CASTINGS



How about

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HEAT TREATING TRAYS
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ANNEALING BELTS
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TUBING

DURALOY

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Heat Resistant

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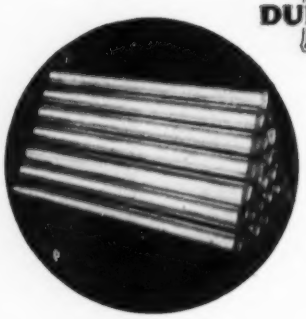

When ready to order, how about checking with us here at DURALOY? For more than thirty years we have specialized in high-alloy castings. In fact, we were among the first to produce static castings and the first to produce centrifugal castings. We are old hands at producing castings alloyed to fit each specific requirement and to finish them to any extent desired.

Melt, castings and finishing are carefully controlled and quality tested by our staff of metallurgists, chemists, X-ray and gamma-ray technicians. If you would like more preliminary information, send for Bulletin No. 3150-G.

THE DURALOY COMPANY

Office and Plant Scottdale, Pa. · Eastern Office 12 East 41st Street New York 17, N.Y.

Remedy for Hydrogen in Brass Sheets*

BLISTERING of a severe and persistent sort in sheets of 2:1 and cartridge brass (70 Cu, 30 Zn) was studied from mechanical and chemical standpoints. The sheet was made from chill-cast ingots by breaking down hot and subsequent rolling cold, after surfacing, with intermediate anneals. Considerable amounts of crossrolling were involved.

The blisters first appeared after annealing when the sheets were something less than ⅛ in. thick, depending upon the thickness of the original ingot; they developed exclusively near the center plane of the sheet. Drilled under vacuum, these blisters released gas which proved to be virtually pure hydrogen. The pressure within the blister had been approximately one-half atmosphere at room temperature.

Because the gas analysis precludes any assumption of an origin other than precipitation from the metal lattice, the inquiry was limited to three considerations: (*a*) the source of the hydrogen dissolved in the metal, (*b*) the variation of this hydrogen content during processing, and (*c*) the origin of the cavities in which it precipitates.

Test ingots approximately 1¼ in. thick and 3 ft. long were chill-cast in vertical cast iron molds which were coated with a mixture of lard oil and resin which volatilized during pouring and burned at the mouth of the mold. Pouring was done through a tundish with a number of holes, and it was completed in 10 to 15 sec. Analyses of hydrogen content, determined by vacuum extraction, showed a considerable value for the ingot, this being successively lowered in the preheating and the annealing furnaces. For example, one ingot gave 0.29 cc. per 100 g., which was reduced to 0.14 cc. per 100 g. in the hot rolled plate. In fact, annealing at 1470° F., proved to be so effective for removing hydrogen that after 15 min. at this temperature the content in ¼-in. plate was reduced to 0.01 cc. per 100 g. Corresponding

(Continued on p. 198)

*Digest of "Hydrogen Blisters in Brass Sheet", by R. Eborall and A. J. Swain, *Journal* of the Institute of Metals, Vol. 81, July 1953, p. 497-500.

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SPOT WELD without jigs or back-up plates

Now you can spot weld with complete maneuverability — and as fast as you can pull the trigger — with the new portable AIRCOSPOT® Gun.

With **AIRCOSPOT,** Air Reduction's new inert-gas-shielded spot welding unit, you simply touch the water-cooled gun to one side of the work and pull the trigger. In about a second you have a spot weld. It will be a good one, too, because **AIRCOSPOT'S** inert gas shield completely protects the hot metal from contamination by the air.

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Remedy for Hydrogen in Brass Sheets

(Continued from p. 196)

times for other plate thicknesses may be obtained by multiplying this value by the square of the thickness ratio. These results suggest a remedy for blistering by reducing the hydrogen content at a sufficiently early stage to allow subsequent flattening and fusing of the cavities. As for these cavities, it is presumed that they result from hydrogen precipitation within shrinkage cavities during solidification.

In the course of this work, an opportunity was also taken to measure the hydrogen solubility of 2:1 brass. Sound sections of gas-free metal were soaked in hydrogen, quenched and analyzed. The results were substantially lower than those reported in the literature for copper.

There is some indication that the hydrogen solubility increases when the beta phase is present.

C. A. ZAPFFE

Crucibles for Difficult Jobs

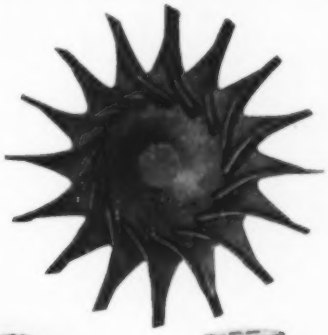
A 28-PAGE BOOKLET has been put together by M. A. Schwartz, G. D. White and C. E. Curtis of Oak Ridge National Laboratory under the title "Crucible Handbook; a Compilation of Data on Crucibles Used for Calcining, Sintering, Melting and Casting". Its identification number is ORNL-1354. It lists the names of 25 manufacturers of ceramic crucibles, gives the stock sizes and describes the characteristics of the principal types, and lists the important references in recent technical literature. In addition to this information on the more or less conventional materials (alumina, beryllia, graphite, magnesia, mullite, silica, silicon carbide, thoria and zirconia) a short section presents methods whereby the research worker can manufacture his own crucibles out of the refractory nitrides or sulphides. A data sheet is included giving recommended practices for the melting of unusual metals, or melting of the usual metals when contamination must be kept to a minimum.

WAUKESHA CORROSION-RESISTANT ALLOYS include

WAUKESHA 347

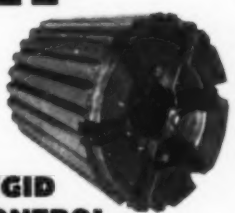
(Columbium Stabilized)

STAINLESS STEEL



Tough, highly resistant to corrosion and to extremely high temperatures, WAUKESHA'S No. 347 Columbium Stabilized Stainless Steel may be vitally important in improving your product. You may benefit by using it in valves, pressure fittings, parts in large weldments difficult or impossible to heat treat — or other parts subject to high temperatures (over 800°F.) either in production or in end use.

WAUKESHA No. 347 Columbium Stabilized can be welded successfully without heat treatment, and without impairing its high corrosion-resistant characteristics.



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How to Find The Right Finish for Zinc

How one plating shift did the work of two

In hard chromium plating of airplane parts, a company was getting a rough deposit. They had to deposit the .004" of chromium slowly to avoid excessive grinding and polishing. The slow rate meant running over to a second shift to meet schedules.

Then the ordinary chromium bath was replaced by the Unichrome SRHS Solution. This 20% to 80% speedier bath has leveling action. Result: A *smoother* .004" plate, in only 3 hours—saving enough time to meet schedules in one shift instead of two.

MORE TOLERANT NICKEL BATH—MORE OUTPUT

A plant installed the Unichrome Bright Nickel process alongside a larger tank of another nickel solution. Both plated identical parts. Yet Unichrome Nickel turned out more work. It tolerated impurities so much better that it took less time out for purification. (Now it occupies *both* tanks).

New finishes from time-tested copper bath

Two new addition agents have been developed for the Unichrome Pyrophosphate Copper Process. One produces a uniform satin finish of unusual buffability; the other, a brighter finish that can eliminate need for copper buffing entirely. Both agents increase plating speed.

Whether used with or without these agents, Unichrome Copper's dense deposit makes an excellent stop-off prior to nitriding or carburizing.

UNITED CHROMIUM, INCORPORATED
100 East 42nd St., New York 17, N. Y.
Waterbury 20, Conn. • Detroit 20, Mich.
Chicago 4, Ill. • Los Angeles 13, Calif.
In Canada:
United Chromium Limited, Toronto, Ont.

Complete line of chromate treatments gives finishers greater control over type of process, color, costs and operating method

Improved chromate-treating methods have been largely responsible for the increased use of zinc as a finish in the past several years. For several reasons. They give zinc the extra protection against corrosion required by Government specifications. They can produce attractive decorative finishes. They provide a base for better adhesion of paint and lacquer.

Today, United Chromium offers metal finishers and designers the most complete line of chromate treatments available. This wide choice results in substantial benefits because it means a finish not "almost as good as" but rather the one that best meets the user's needs.

TWO WAYS TO PROCESS— DIFFERENT COLORS

By straight chemical conversion, Unichrome Dip solutions produce black, olive drab, brass-yellow, iridescent yellow or clear chromate coatings in 5 seconds to 2 minutes. The black and olive drab processes can produce finishes with the eye appeal of glossy enamel. Unichrome Dips use simple equipment, minimize installation costs.

The Anozinc* processes produce black, yellow or clear coatings *electrolytically*. These are tough, very economical finishes that can be handled while wet.

With both Anozinc and Unichrome Dip processes, the finish becomes an integral part of the zinc coating.

WHAT THE RIGHT FINISH MEANS

To a company treating zinc plated hardware, Unichrome Dip No. 95 means better "mileage" and a brighter, more corrosion resistant finish than formerly obtained.

To a plating superintendent, Unichrome Dip No. 98 means reduced costs, because he uses only half as much compound as before in make-up, and gets a solution with longer life.

To companies turning out zinc plated shell cases, Anozinc* means more economically producing a uniform, brassy protective finish inside and out. On a run of 26,000 20 mm cases, for example, one company got only 84 rejects.

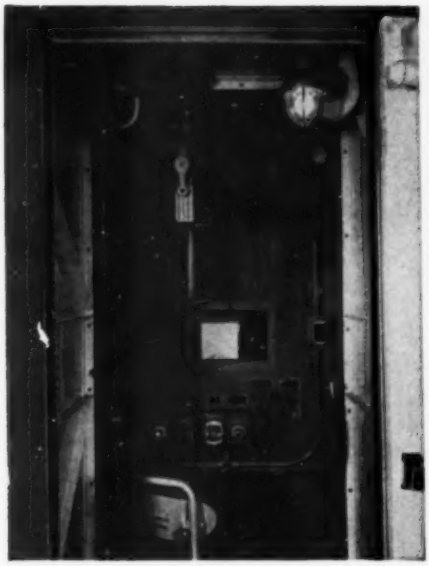
To another user, Unichrome Dip 1081—a *dry* compound—meant reduced shipping costs and fewer glass carboys to handle.

To a well known automotive supplier who replaced a "home made" chromate solution, Unichrome Dip No. 95 meant a 33% saving on materials cost alone.

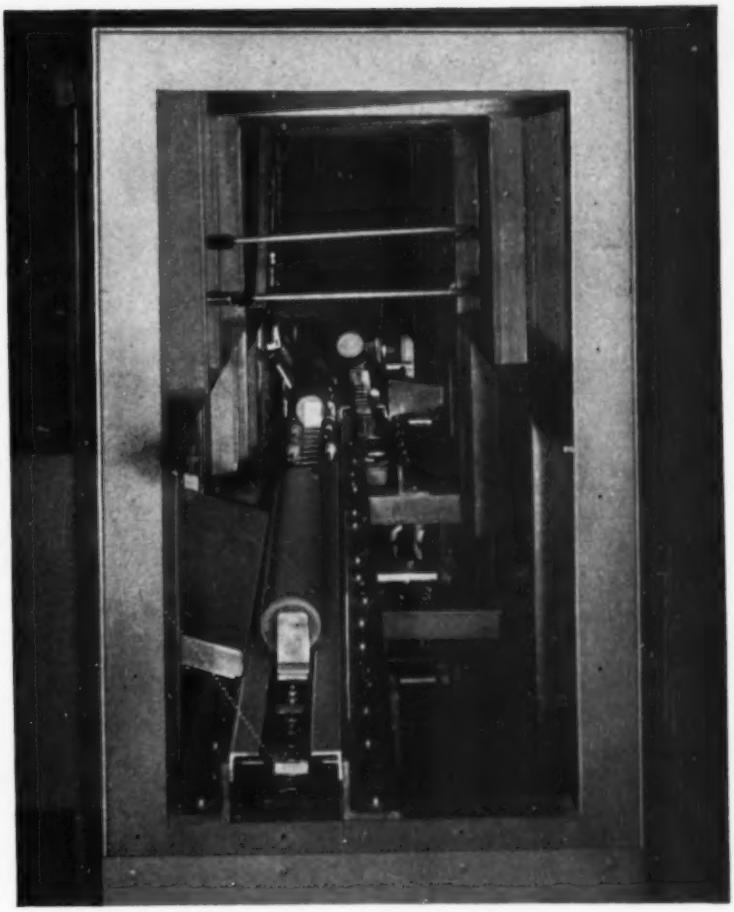
In all cases, using a Unichrome process also means the service and experience of a United Chromium engineer who is often instrumental in ironing out users' operating problems.

SEND FOR SPECIFICATION CHART

A chart to save time and help locate the best-suited chromate-treating material is available. Also Bullein CC-1 describing Unichrome Dips and Anozinc. Write for your copies. **Trade Mark*



Operator's booth is X-ray proof with explosion-proof fittings; operator has control of speed, flow, inspection position, rejects grains by using push button.



Conveyor has chopper feeder to prevent jamming, carries continuous line past X-ray cone, at right; grain at end has been rejected.

Inspection Problem Solved with

Westinghouse Fluoroscopy

Advisory Service Available

Westinghouse now offers industrial fluoroscopy as well as conventional X-ray techniques. These methods have solved difficult problems.

At the Hercules Powder Plant, in DeSoto, Kansas, for example, the Westinghouse Fluoroscopic unit (above) has been designed for internal inspection of explosive powder grains for airborne rockets. At left is the operator's booth, at right the conveyor. This X-ray unit permits a continuous stream of large, cylindrical grains to be thoroughly inspected by a single operator. Design provides for easy location and identification of defect areas and for the automatic rechanneling of faulty grains. Results: quick, positive, low-cost inspection without costly film and processing requirements.

If you face a tough inspection problem it will pay you to investigate Westinghouse Fluoroscopic equipment. For complete technical assistance to the solution of your particular inspection problems, call your Westinghouse representative — or write Dept. O-68, 2519 Wilkens Avenue, Baltimore 3, Maryland.

X-RAY DIVISION · WESTINGHOUSE ELECTRIC CORPORATION · BALTIMORE 3, MARYLAND

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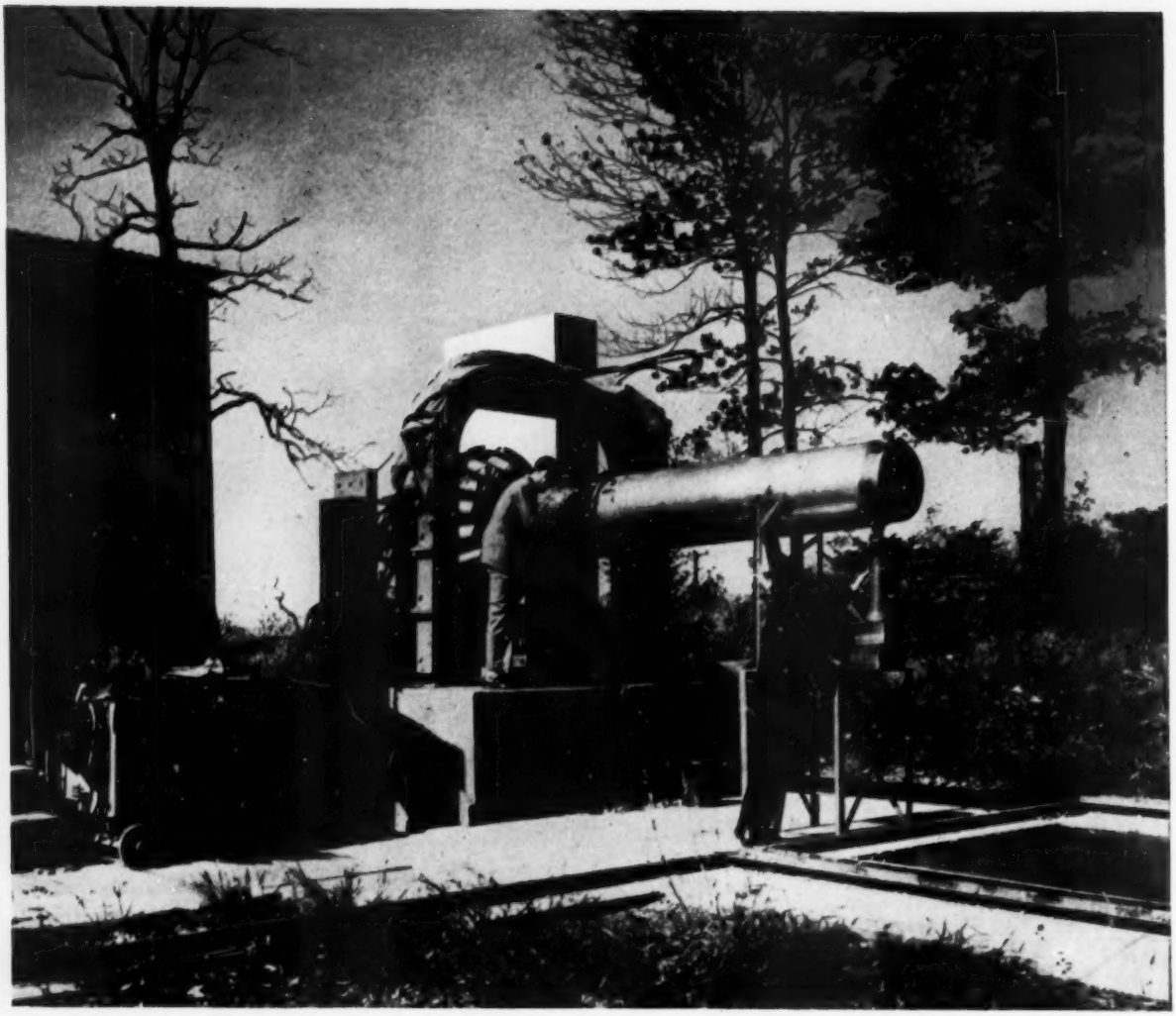

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see our catalog in S PRODUCT DESIGN FILE or write for copy

PIONEERING on the Horizons of Steel

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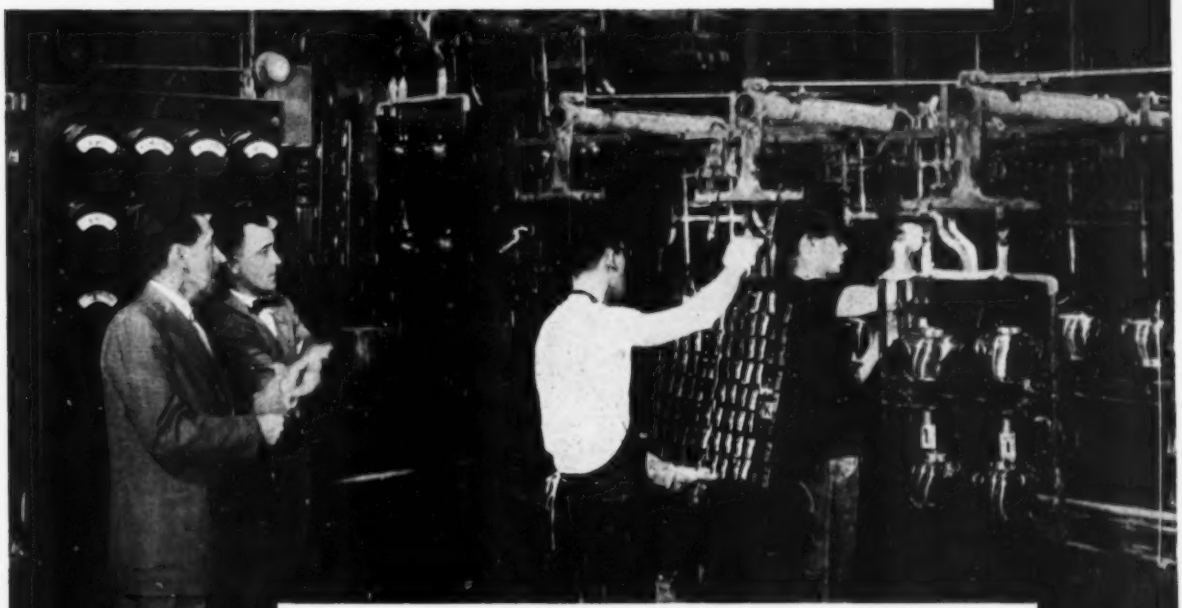
AL LEADING PRODUCER HIGH-ALLOY STEELS

W&D 4491-B

...and here is the double file loading feature of H-VW-M Full Automatic Conveyors



It's easy to see the advantages of this construction—double the capacity with the same machine. When less production is required only one rack is placed on each hanger arm—that's versatility, isn't it?

H-VW-M Full Automatic Conveyors are used daily for all types of plating—as well as anodizing, pickling, cleaning, phosphate coatings, bright dipping, painting, etching, and other finishing processes. They operate in a wide range of weight, current loads, and lifts. And they can be built with delayed set-down for varying immersion time, treatment by-pass mechanisms, air and solution agitation, racks with individual electrical control for each rack, or whatever special equipment the job requires—the ideal solution to problems of large quantity, high quality plating.

Full Automatic Conveyors are only one of many results of H-VW-M's more than eighty years of constant electroplating development. It's a continuous policy, best summed up in H-VW-M Platemanship...your working guarantee of the best that industry has to offer—not only in plating conveyors—but in every phase of plating and polishing.

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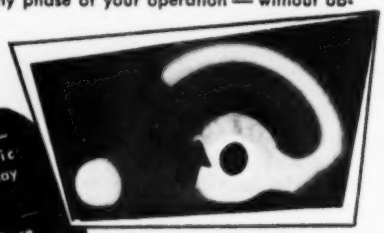

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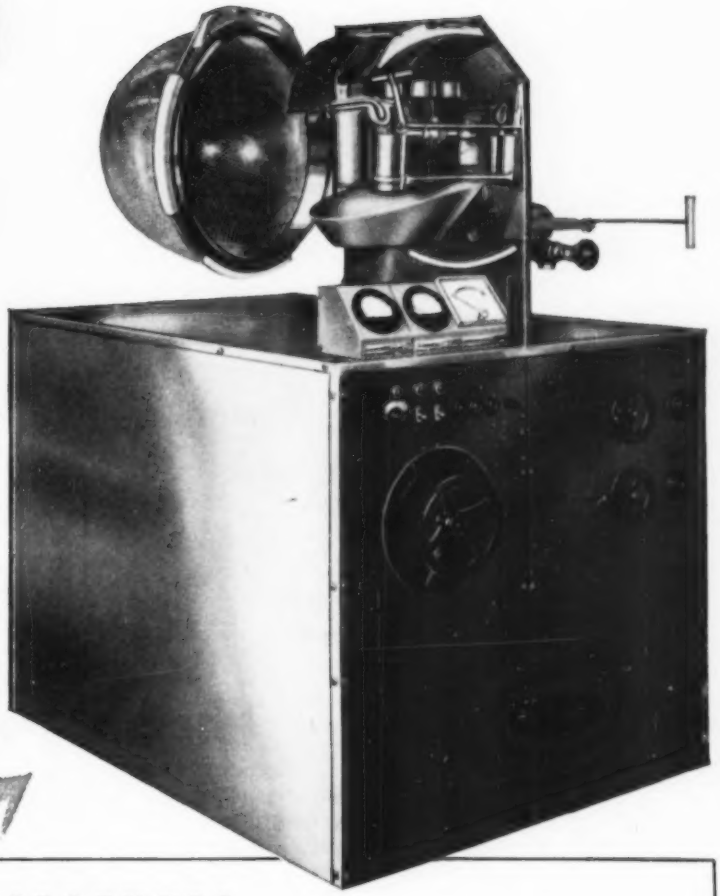

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With this new furnace you can melt and solidify — melt and pour — add to the melt — stir — look into the hot zone — measure hot zone temperatures — introduce controlled atmospheres — degas — heat treat. It's a complete, versatile unit, capable of handling the widest variety of metallurgical research work. Write today.

FEATURES

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- Working temperatures up to 2000° C.
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- Manual temperature control. (Automatic control optional.)
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Does any job in the following list give you trouble? If you'll circle the corresponding number in the coupon, we'll be glad to tell how we can help you.

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1 Cleaning aluminum, steel and magnesium
2 Stripping paint (solvent or hot tank)
3 Machining, grinding, forming
4 Deoxidizing aluminum
5 Steam cleaning aluminum and steel
6 Deflocculating paint in spray booths
7 Preparing metal for painting
8 Removing scale and corrosion
9 Preventing corrosion

FREE Our 48-page illustrated booklet "*How to Clean Metals in Aircraft Production*" contains information on all the cleaning jobs in the list.

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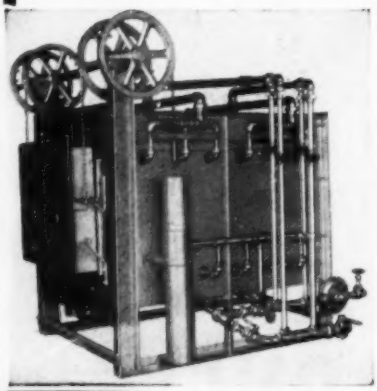
A FULL LINE MADE by the PIONEERS



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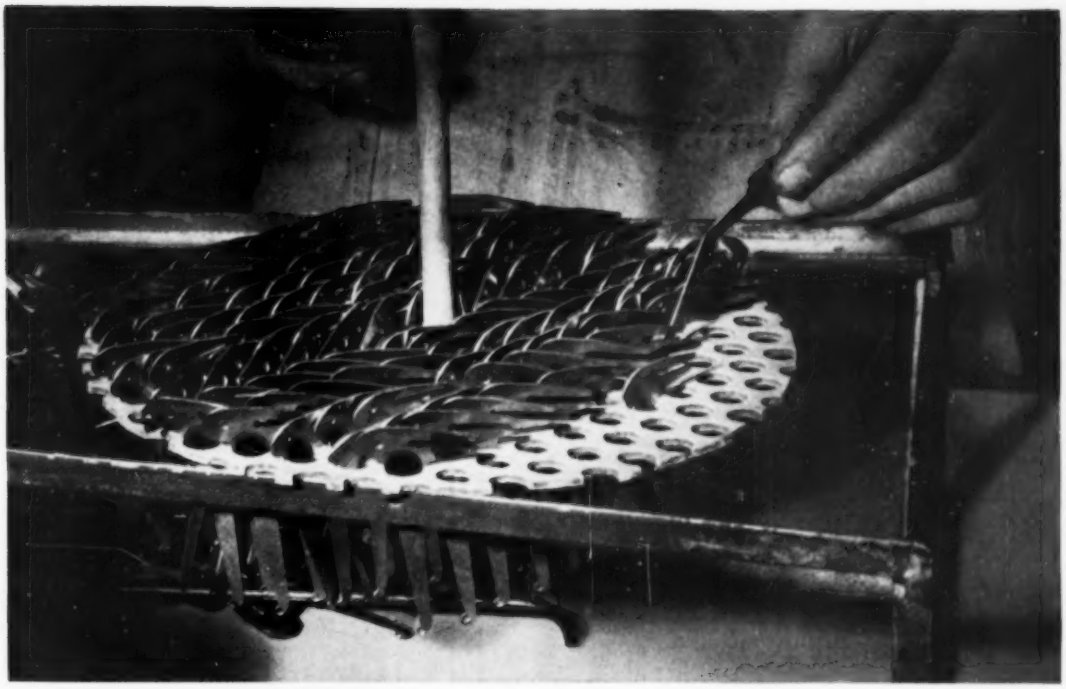

An Incoloy rack is being loaded with cold-rolled steel bell cranks for eight minutes heat treating in a 1575° cyanide salt bath.

How Incoloy racks cut replacement costs 90% in 1575°F. cyanide salt bath

Cold-rolled steel parts for Underwood typewriters have to be in perfect alignment in order to function properly. And they are heat treated in a 1575° – 60% cyanide salt bath for eight minutes to give them extra strength and wear-resistance.

That's where Underwood Corporation used to have trouble.

At first the parts were heat treated in mesh baskets – but the time required to straighten out-of-line parts forced this method to be abandoned.

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Finally an Inco Nickel Alloy – high-temperature- and corrosion-resisting Incoloy® – was tried.

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Incoloy, companion alloy to Inconel®, has unusual resistance to many types of corrosion encountered in heat treating processes. It has good strength at temperatures up to 1850° F. And it is readily welded and fabricated.

For more information on this recent member of the Inco family, write for your copy of "Progress Report on Incoloy." And if you have a special heat treating problem, write Inco's Technical Service Section for help.

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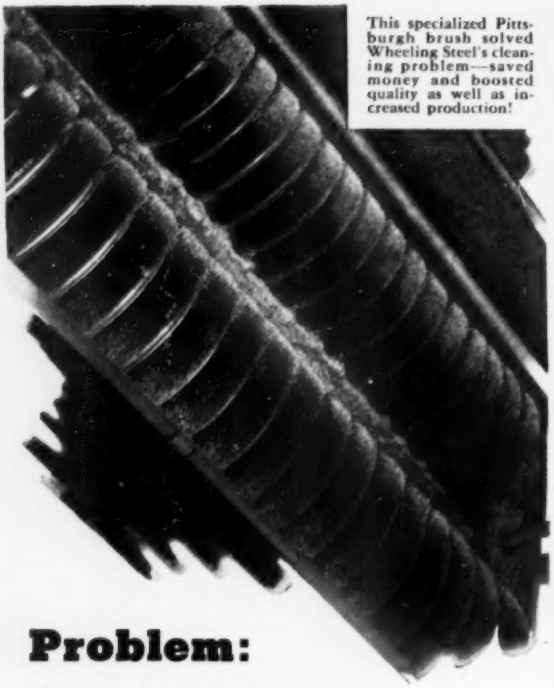

This specialized Pittsburgh brush solved Wheeling Steel's cleaning problem—saved money and boosted quality as well as increased production!

Problem:

How to be tough and soft at the same time!

That was the problem presented to the Pittsburgh Plate Glass Company by the Steelcrete Division of Wheeling Steel, Beech Bottom, W. Va.—and it required a specialized Pittsburgh brush to solve it!

Large sheets of expanded metal had to be cleaned without impairing the surface texture, yet the brush had to cut through tough scale and remove burrs. A special steel wire was chosen, made up into brushes, and applied to the problem. Result? Combining the right amounts of toughness AND softness, the brush completely eliminated burrs in a matter of minutes, leaving the face of the metal unharmed. Moreover, cleaning is quicker and costs less than with other brushes!

WRITE TODAY for your free copy of our new booklet that shows, thru actual case histories, how Pittsburgh can help cut *your* brushing costs. Address: Pittsburgh Plate Glass Company, *Brush Div.*, Dept. W-14, 3221 Frederick Ave., Baltimore 29, Md.

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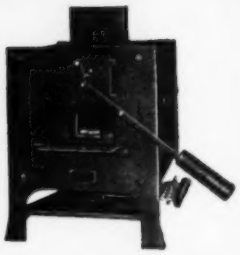
Designed primarily for high carbon and alloy steels.



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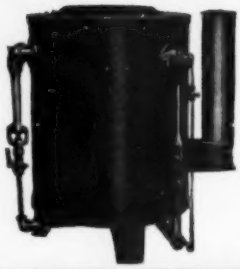

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General Discussion and Indexes.

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MOST SIGNIFICANT LAUNCHING IN HISTORY

AT the launching of the NAUTILUS, Navy's Nuclear Powered Submarine, we shared a general, and profound, conviction that we were witnessing the *most significant event since the advent of steam.* An illustrious gathering of Government and Military Chiefs mingled with the Naval Officers, Engineers, Scientists and Craftsmen, whose sleek, functional, potent Tool-of-Freedom awaited Christening by our First Lady. The Nautilus, poised precisely for her historic flight-to-flotation, dynamically personified the verity "That which is truly Functional is truly Beautiful."

ALL heads were high, eyes bright, and hearts swelling with pride, as appropriate words of Prayer, of Tribute, and of Prophecy, were spoken,—and "Mamie" competently swung the traditional Champagne Bottle precisely on the AMERICAN "nose" *that leads, by years, in the Atomic race.* The radiance of "Mamie's" face, reflected in smiles of the crew tending the cradle wedges, of Newsmen, of V.I.P.'s and of workers' families, *testified eloquently that* THIS WAS A GREAT DAY FOR ALL AMERICANS, as the Nautilus left the ways of the Electric Boat Company (Div. General Dynamics Corp.) into the Thames River at Groton, Connecticut, January 21.

LIKE every major departure-from-precedent, the Nautilus began as a revolutionary concept in the minds of men of VISION. It is well that they, too, possessed great COURAGE and DETERMINATION, for, from the outset, they met the impedances which blind, small, stupid and jealous men *contrive to place* in the path of PROGRESS.

BEYOND the psychological and political strictures, those who conceived, sponsored, and DELIVERED the Nautilus, faced almost overwhelming technical obstacles in the limitations; of knowledge, materials, weight, space;—and in harnessing potent hazards. Their success in transcending such barriers, in scaling new heights of Science, and in advancing U. S. Technology to NEW HORIZONS, (now scheduled for crossing), is a potent INSPIRATION to Free Men, and a WARNING to their enemies.

SIMPLY stated, Nuclear Power is "Potentially limitless power, without a gas tank, and no stops at the pump. Only the crew needs 'refueling,' you run until your groceries give out." No air is required for Nuclear engines, and they give off no fumes. Nuclear power projects vastly higher submerged speeds, below the resistance of waves and wind, substantially unlimited Range, and size capable of carrying cargo equal to a hundred or more of the largest planes. The low speeds of submerged submarines, running on small battery powered motors, and their necessity for surfacing at short intervals, their limited range and speed hazarding ESCAPE, from pursuers, all have handicapped their development. Nuclear SUBMARINES: CARRIERS, Missile Launchers, capable of launching the largest, most potent "Ground to Ground" missiles, and rockets in large numbers *with terrific fire power.* Troop Transports, that can "stand-by" for weeks or months, all are *in the cards.*

REMEMBER, that far more enemy tonnage in the Pacific was sunk by U. S. Submarines than by Air Power. German submarines, in two wars, destroyed thousands of ships and billions in cargo. A German cargo submarine discharged cargo on our shores without detection. Nuclear Submarines will be harder to find, less vulnerable to attack, and have more freedom of operation than any ship or plane. They can RUN DOWN AND DESTROY other subs. It is improbable that a weapon, as potent as present missiles, against Bombers, will be developed against Nuclear Subs, or that detectors can locate them within a small fraction of their range and accuracy in detecting Aircraft.

THE Nuclear Powered Plane is a certainty. It will be able to circle around the Polar Cap, or circle the Globe indefinitely, carrying a load of "Homing" missiles. It will not have the benefit of "Invisibility." It will lack the speed of attacking supersonic fighters and missiles.

THIS is written before a log fire, burning on andirons fashioned from a long-boat Anchor, and rudder chain from "Old Ironsides," (U. S. Frigate Constitution). The mantle-piece is a 10 x 10 live oak stanchion from her gunwales. Musing back to "Iron Men in Wooden Ships," and the glorious ENGINEERING, as well as FIGHTING,—TRADITION of our NAVY, we recall that, at the birth of this Nation there existed no engineering remotely comparable in scope, or complexity, with Ship Construction.

THE Architect of structures and edifices on static foundations, for example, had no problems remotely comparable in magnitude, or complexity, to those confronting the Shipbuilder and Marine Engineer. Even today the largest airplane, a "Rockerfeller City" development, or an entire sizable city, contains only a small fraction of the highly integrated arts, crafts and sciences, the power, machines, services, and devices, from communication, electronics, and fire protection, to food preparation, refrigeration and hydraulics of a great ship.

FROM such inspiring and eminently qualifying technical Heritage, Naval Engineers have, in the Nautilus, established an initial World Leadership in a new field. *May she, and her successors, be speedily and repeatedly obsoleted by CONTINUED,* ACCELERATED U. S. ADVANCES in Nuclear Power, and Atomic Development.

ONLY by technical SUPERIORITY, and IMPROVED MASS PRODUCTION TECHNIQUES, can we overcome WITH HIGHER BRAIN-to-MASS RATIO, the rising Tide of Communist Hordes, supplied by the growing slave-labor force of duped and conquered peoples.

General Alloys Company solicits your inquiries for heat and corrosion resistant castings designed and produced with full employment of GA's unequalled record of achievement in engineering, metallurgy and casting techniques.

Please contact our Office or Representative in your area, or write, wire or phone direct to 405 West First Street, Boston, Mass.

An editorial by the President of General Alloys Company, Boston, "oldest and largest exclusive manufacturer of heat and corrosion resistant castings".

THE FOOTSTEPS OF GENERAL ALLOYS MARK THE PATH OF AN INDUSTRY

GA X-ITE GA CALLITE GA X-ITE GA CALLITE

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REFRACTORY CONCRETE made with Castables is the *adaptable* refractory. Easy to place in any size or shape.

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In fact, you'll find Castables tailor-made for speed and convenience on many Refractory Concrete jobs. Handy for repairs, too.

CASTABLES to meet specific temperature and *insulation* requirements are made by manufacturers of refractories and sold by their distributors. For further information, write to LUMNITE DIVISION, Universal Atlas Cement Company (United States Steel Corporation Subsidiary), 100 Park Avenue, New York 17, N. Y.

**"LUMNITE" is the registered trade mark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.*

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Because of its unusual design, this heat exchanger has two to eight times the heat-transfer of plain bare pipe or tubing. HASTELLOY alloy B gives the assembly the necessary corrosion resistance. The exchanger, which was formed from alloy B strip, pipe, and elbows, handles hot chloride-bearing chemicals.

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A HASTELLOY alloy C safety valve similar to the one being lapped here was inspected recently after handling 500 "pop" reliefs of scalding acid vapors. It was found that the alloy surface still had its original polished finish.

HASTELLOY *alloys can help solve your corrosion problems, too. For further information, contact the nearest Haynes Stellite Company office listed below.*

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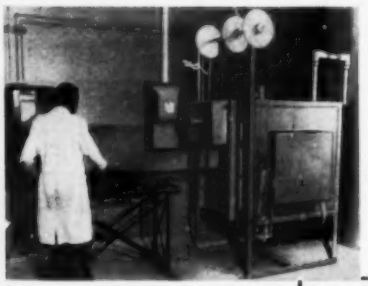

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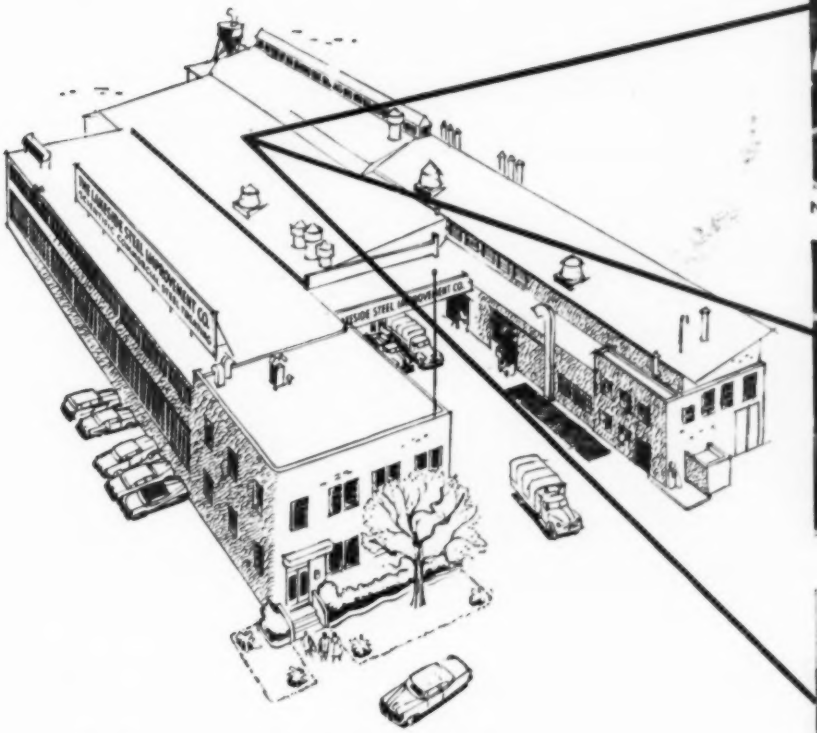
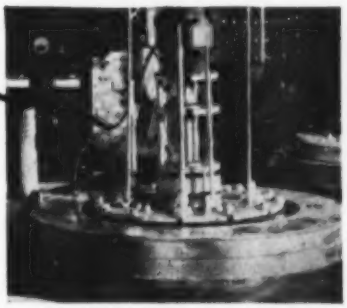
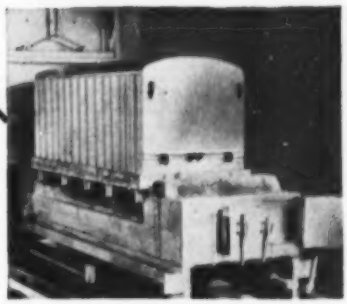


New semi-continuous type furnace at Lakeside



Recently-installed pit-type furnaces



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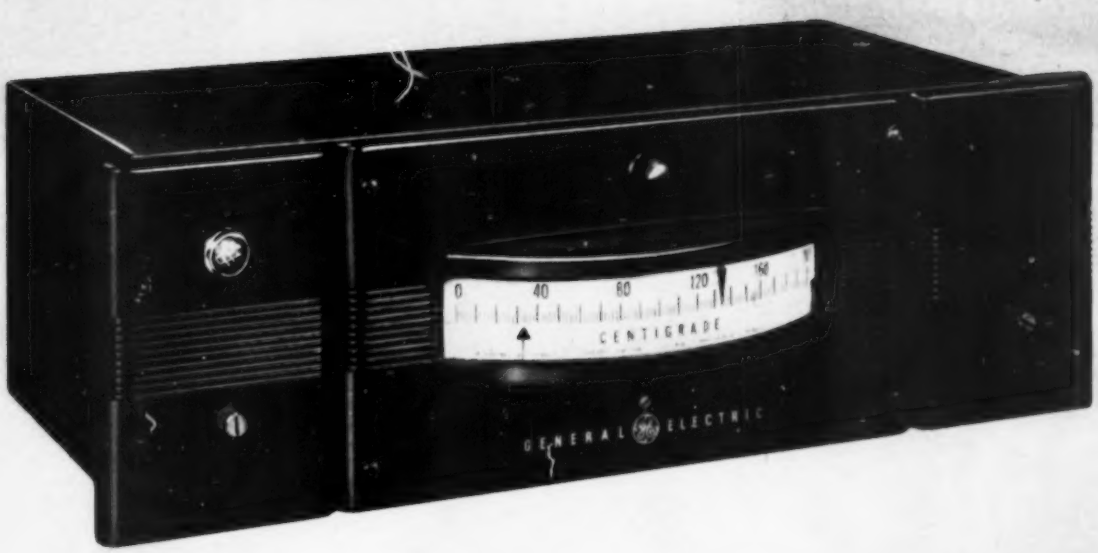

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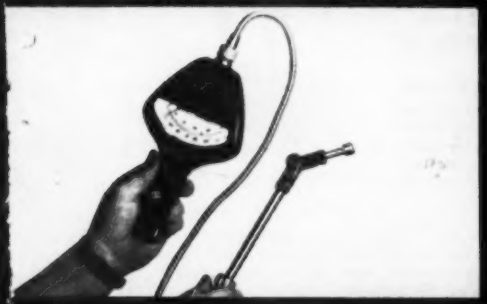

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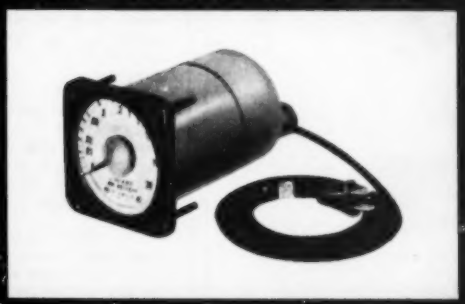

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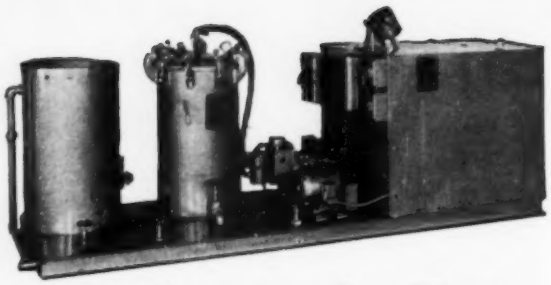

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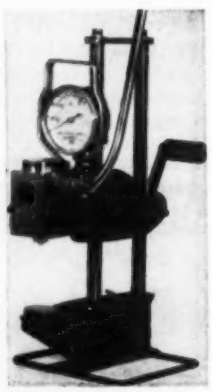

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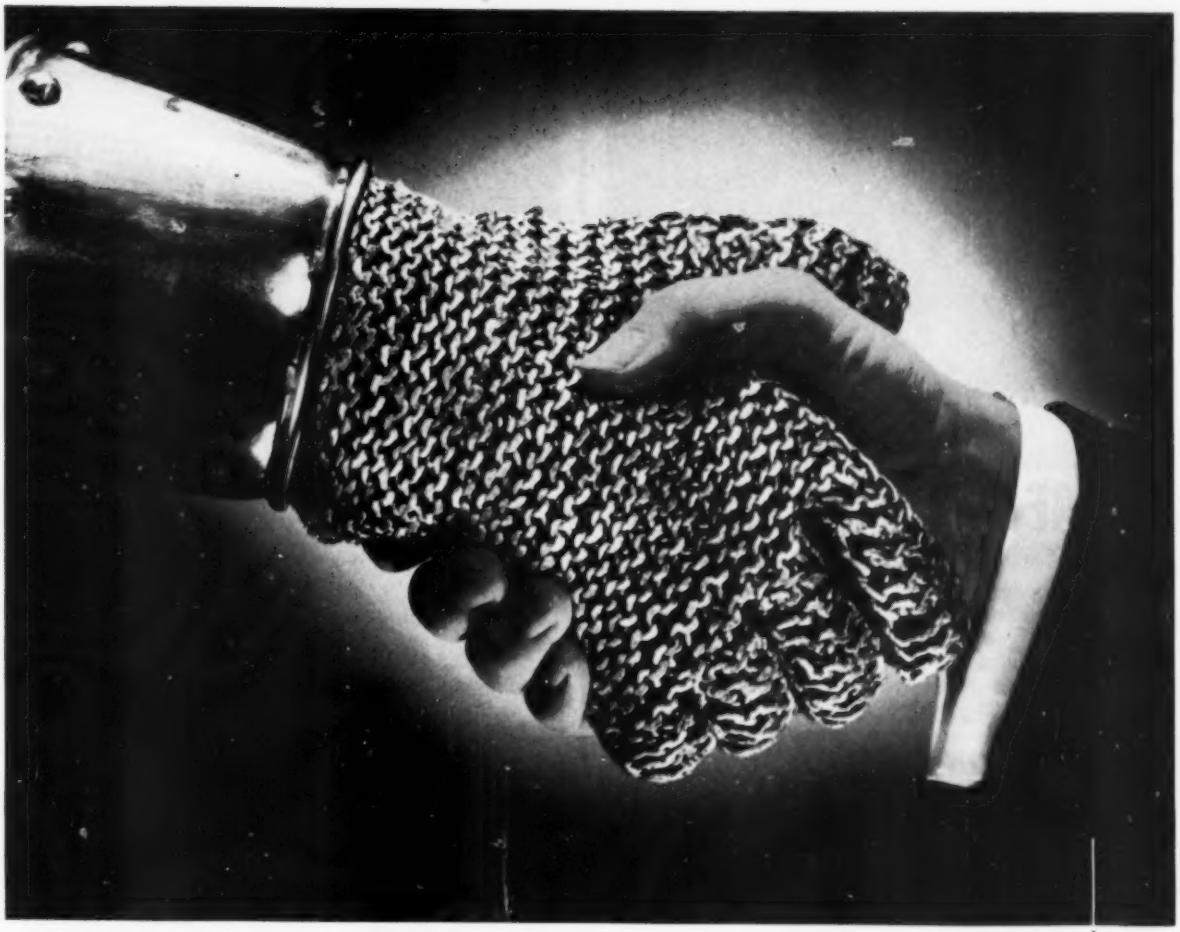

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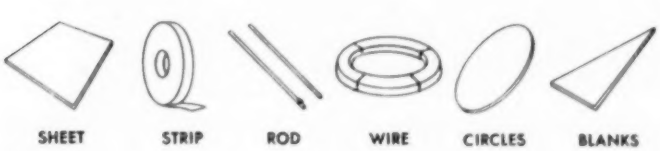

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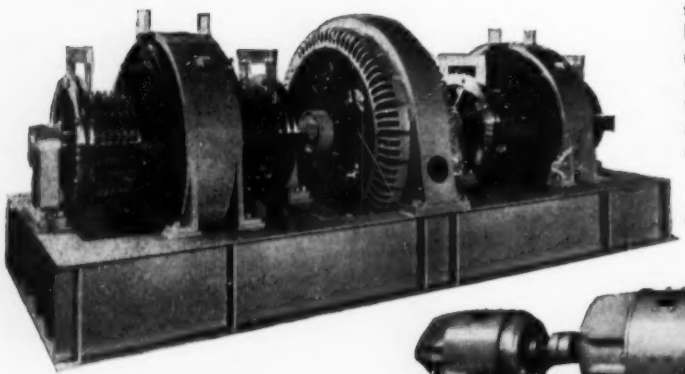

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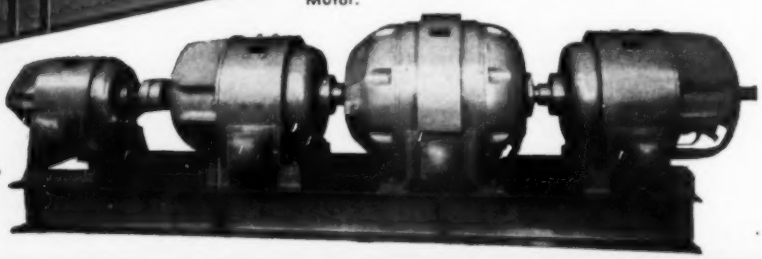

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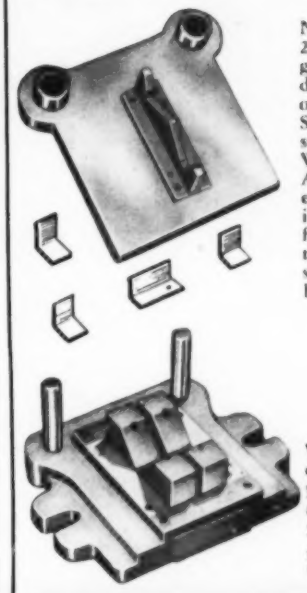

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• Index to Advertisers •

Acheson Colloids Corp. 32F
Air Reduction Co. Inc. 197
Ajax Electric Co. 35
Ajax Electrothermic Corp. 49
Aldridge Industrial Oils, Inc. 146, 154
Allegheny Ludlum Steel Corp. 202
Allied Research Products, Inc. 138
Alloy Engineering & Casting Co. 195
Almco Div. 150
Alpha Corp. 154
Alvey-Ferguson Co. 174
American Brass Co. 133
American Cast. Iron Pipe Co. 54
American Chemical Paint Co. 137
American Gas Furnace Co. 206
American Machine & Metals, Inc. 8
American Roller Die Corp. 13
American Society for Metals 192, 219
Ames Precision Machine Work 126
Applied Research Laboratories 19
Armour & Co., Ammonia Div. 213
Ashworth Brothers, Inc 218
Atlantic Chemicals & Metals Co. 154

Baker & Co., Inc. 188
Barber-Colman Co. 204
Bausch & Lamb Optical Co. 96D
Bell & Gossett Co. 160B
Bel-Ray Co., Inc. 154
Beryllium Corp. 131
Bethlehem Steel Co. 20
Bigelow-Liptak Corp. 125
Boder Scientific Co. 156
Branson Instruments, Inc. 156
Bristol Co. 48
Bundy Tubing Co. 171
Buehler, Ltd. 165
Burrell Corp. 144

Cambridge Wire Cloth Co. 114
Campbell Div., American Chain & Cable Co. 177
Carborundum Co. 57, 96C
Carl-Mayer Corp. 166
Carlson, Inc., G.O. 184
Carpenter Steel Co. 160
Chase Brass & Copper Co. 38
Chemical Corp. 192
Chicago Steel Foundry Co. 212
Cincinnati Milling Machine Co. 26-27
Cities Service Oil Co. 12
Clark Instrument Co. 174
Cleveland Crane and Engineering Co. 151
Cleveland Metal Abrasive Co. 151
Climax Molybdenum Corp. 190
Cold Metal Products Co. 16-17
Columbia Electric Mfg. Co. 218
Columbia Tool Steel Co. 170
Consolidated Vacuum Corp. 135
Cooley Electric Mfg. Corp. 146
Copperweld Steel Co. ..... Back Cover
Crucible Steel Co. of America 33, 55, 187

Deakin & Son, J. Arthur 155
Dempsey Industrial Furnace Corp. 148
Despatch Oven Co. 122
Detroit Testing Machine Co. 135, 194
Dice Co., J. W. 155
Dow Furnace Co. 128
Drever Co. 191
Driver-Harris Co. 179
Du-Lite Chemical Corp. 150
Duraloy Co. 196
duPont de Nemours & Co., Inc. 63

Ekstrand & Tholand, Inc. 153
Electric Furnace Co. ..... Inside Back Cover
Electro Alloys Div. American Brake Shoe Co. 2
Electro Metallurgical Co. Unit of Union Carbide and Carbon Corp. 111
Engineered Precision Casting Co. 153
Erico Products, Inc. 152
Enthone, Inc. 37

Fahralloy Co. 158
Finkl & Sons Co., A. 41
Firth Sterling, Inc. 189

Gas Machinery Co. 176
General Alloys Co. 209
General Electric Co. 215
Gordon Co., Claud S. 188
Great Lakes Carbon Corp. 60
Great Lakes Steel Corp. 127
Gries Reproducer Corp. 153
Gulf Oil Corp. 59

Hangsterfer's Laboratories 154
Hanson-Van Winkle-Munning 203
Harshaw Scientific Div. Harshaw Chemical Co. 129
Haynes Stellite Corp. Unit of Union Carbide & Carbon Corp. 211
Hayes, Inc., C. I. 181
Hays Corp. 146
Hevi Duty Electric Co. 30-31
Himmel Brothers Co. 152
Holcroft & Co. 32A
Hones Inc., Chas. A. 208
Hooker Electrochemical Co. 167
Hoskins Mfg. Co. 34
Houghton & Co., E. F. 50
Hunter Douglas Corp. 32E

Industrial X-Ray, Inc. 204
Industrial Heating Equipment Co. 147
Institute of Metals 208
Insulation & Wires, Inc. 157
International Nickel Co. 96A, 207
Ipsen Industries, Inc. 173

Jelliff Mfg. Corp., C. O. 150
Jessop Steel Co. 176A
Jet Combustion, Inc. 120
Johns-Manville 40

Kemp Mfg. Co. 141
Kent Cliff Laboratories 156
King Co., Andrew 216
Kinney Mfg. Co. 194

Lake Erie Engineering Corp. 6-7
Lakeside Steel Improvement Co. 149
Latrobe Steel Co. 32C
Lavin & Sons, Inc. 139
Lebanon Steel Foundry 134
Leeds & Northrup Co. 32D
Leitz, Inc. E. 51
Lempco Products, Inc. 15
Lepel High Frequency Labs. 58
Lindberg Engineering Co. 61
Lindberg Steel Treating Co. 149
Linde Air Products Co. Unit of Union Carbide & Carbon Corp. 32
Little Falls Alloys 152
Lord Chemical Co. 190
LR Heat Treating Co. 148
Lucas-Milhaupt Co. 29
Lumnite Div. 210

Magnetic Analysis Corp. 155
Manhattan Rubber Div., Raybestos-Manhattan, Inc. 151
Martindale Electric Co. 168
Maurath, Inc. 153
Medart Co. 142
Meriam Instrument Co. 155
Merrill Bros. 216
Metallizing Co. of America 216
Metal Treating Institute 28
Metal Hydrides, Inc. 132
Midland Industrial Finishes Co. 172
Midvale Co. 24
Milne & Co., A. 42
Minneapolis-Honeywell Regulator Co. (Industrial Division) 4-5, 56
Misco Fabricators, Inc. 186
Monarch Steel Co. 52
Mueller Brass Co. 18

National Carbon Co. Unit of Union Carbide & Carbon Corp. 45
National Forge & Ordnance Co. 46
National Research Corp. 205
Nitrogen Division Allied Chemical & Dye Corp. 51
Norton Co. 22

Oakite Products, Inc. 206
Olsen Testing Machine Co., Tinius 121

Park Chemical Co. 150, 185
Pereny Equipment Co. 212
Peters-Dalton, Inc. 130
Peterson Steels, Inc. 166
Pittsburgh Plate Glass Co. 208
Pressed Steel Co. 113
Production Specialties, Inc. 154
Puritan Mfg. Co. 150

Ra-Diant Products Co. 146
Radio Corp. of America 198
Raybestos-Manhattan, Inc., Manhattan Rubber Div. 151
Republic Steel Corp. 183, 214
Revere Copper & Brass, Inc. 43, 117
Reves, Inc. 204
Richards Co., J. A. 152
Riverside Metal Co. 217
Rockwell Co., W. S. 180
Roll Formed Products Co. 152
Rolled Alloys, Inc. 182
Rolock, Inc. 115
Ryerson & Son, Inc., Jos. T. 6z

St. Joseph Lead Co. 176B
Salem-Brosius, Inc. 160A
Sandvik Steel, Inc. 175
Sargeant & Wilbur, Inc. 124
Saunders & Co., Alexander 168
Scherr Co., Inc., George 23
Scovill Mfg. Co. 169
Sentry Co. 118
Sherman Industrial Electronics Co. 148
Solventol Chemical Products, Inc. 3
Spencer Turbine Co. 159
Standard Alloy Co., Inc. 164
Standard Steel Treating Co. 149
Stanwood Corp. 146
Star Stainless Screw Co. 153
Stokes Machine Co., F. J. 36
Sun Oil Co. 14
Superior Steel Corp. 144A
Surface Combustion Corp. ..... Inside Front Cover
Swan-Finch Oil Corp. 218
Swift Industrial Chemical Co. 148, 151
Sylvania Electric Products, Inc. 178

Taber Instrument Corp. 155
Taylor Sons & Co., Chas. 144B
Tennant Sons & Co. 136
Tenney Engineering Co. 11
Timken Roller Bearing Co. 62
Turco Products, Inc. 39

Union Carbide & Carbon Corp. 32, 45, 111, 211
United Chromium, Inc. 200
Upton Electric Furnace Co. 147

Vanadium-Alloys Steel Corp. 47
Vanadium Corp. of America 193

Waltz Furnace Co. 32B
Ward Machinery Co. 219
Waukee Engineering Co. 170
Waukesha Foundry Co. 199
Webber Appliance Co. 25
Western Products, Inc. 147
Westinghouse Electric Corp. 201
Wheelco Instruments Div., Barber-Colman Co. 10
Wheelock, Lovejoy & Co., Inc. 206
White Metal Rolling & Stamping Corp. 152
Wickwire Spencer Div., Colorado Fuel & Iron Corp. 143
Wiley & Sons, Inc., John 212
Wilson Mechanical Instruments Div., American Chain & Cable 53
Wyckoff Steel Co. 140
Wyman-Gordon Co. 163

Yoder Co., The 123
Young Bros. 219
Youngstown Sheet & Tube Co. 44

Zirconium Corp. 119

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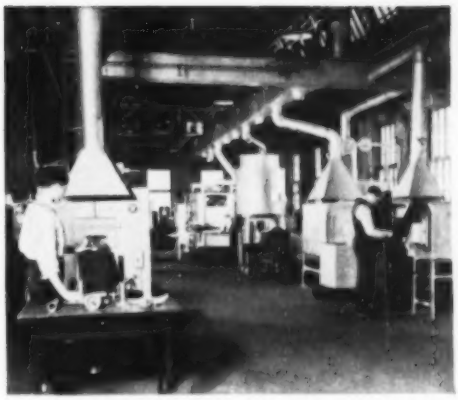

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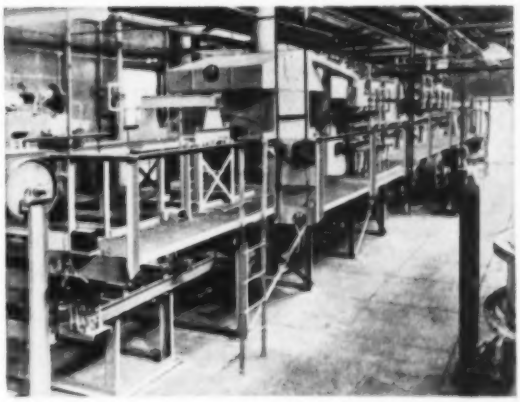

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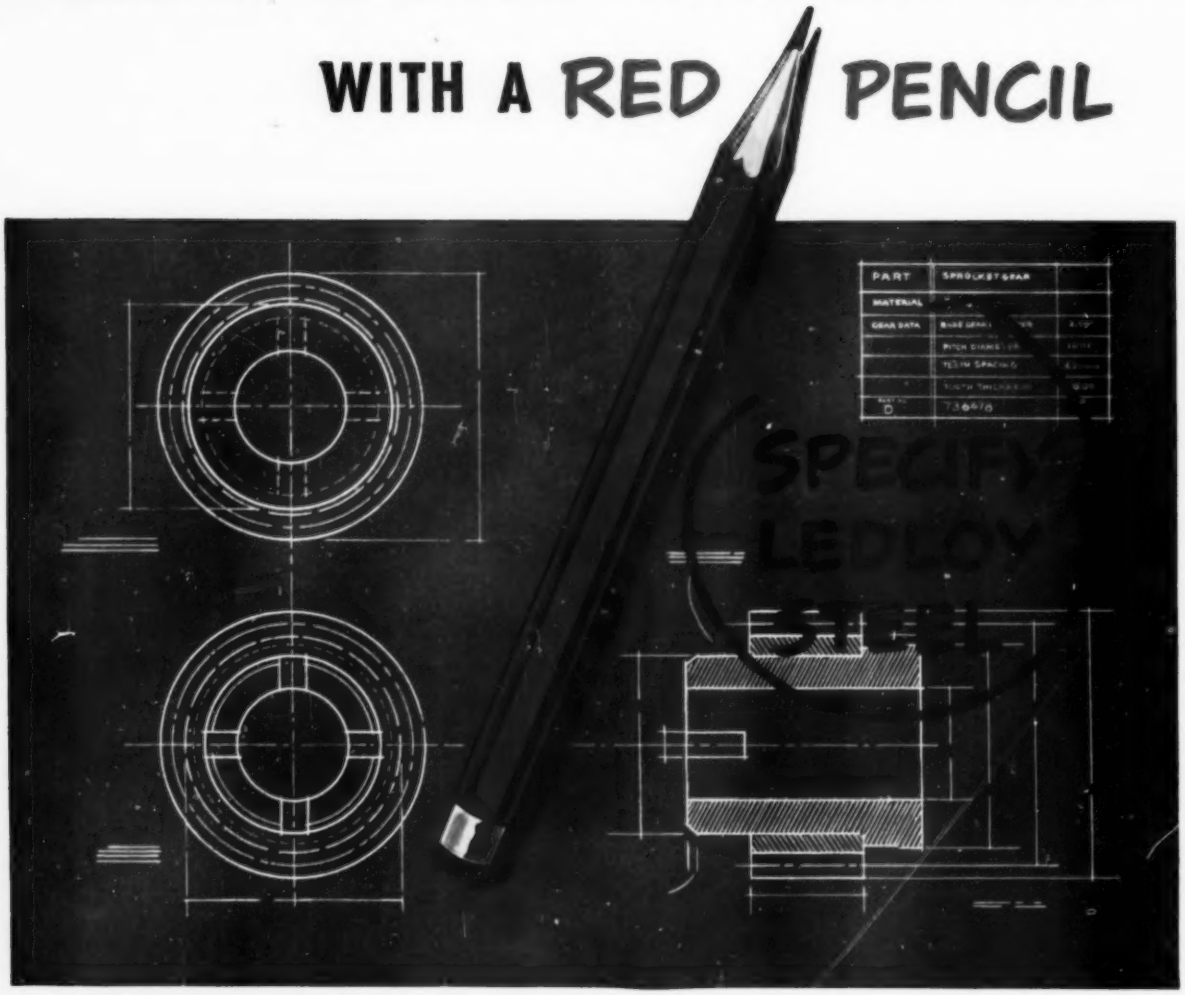

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